R5620-1.32F 12 3 91

RESEARCH REPORT

88

DROUGHT AND FAMINE RELATIONSHIPS IN SUDAN: POLICY IMPLICATIONS

Tesfaye Teklu
Joachim von Braun
Elsayed Zaki

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Research Report 88
International Food Policy Research Institute

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Library of Congress Cataloging-
in-Publication Data
Tesfaye Teklu.
Drought and famine relationships in Sudan : policy implications / Tesfaye Teklu, Joachim von Braun, Elsayed Zaki.
p. cm. — (Research report / International Food Policy Research Institute ; 88)
Includes bibliographical references.
ISBN 0-89629-091-3
1. Famines—Sudan. 2. Droughts—Sudan. 3. Food relief—Government policy—Sudan. 4. Drought relief—Government policy—Sudan. I. Von Braun, Joachim, 1950- . II. Zaki, Elsayed Ali Ahmed. III. Title. IV. Series: Research report (International Food Policy Research Institute) ; 88.

HC835.Z9F38 1991 91-33091
363.8'09624—dc20 CIP

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FOREWORD

Sudan experienced severe food shortages and famines during the 1970s and 1980s. For a country known for its vast agricultural resources, this is both unfortunate and ironic. This research report explores the basic factors that contributed to the recurrence of this phenomenon and identifies policies and actions for avoiding famines and achieving sound and sustainable food policies.

The study demonstrates the complexity of policy for famine prevention, which encompasses macroeconomic reform, promotion of agricultural production and technological change, market development, employment promotion, and interventions for health and nutrition. The researchers extensively investigated all these aspects from primary field data gathered before and after the 1984-85 famine as well as from secondary data. The analysis clearly indicates that famines in Sudan are more often than not a result of long-term policy failures, and in environments of political unrest and weak infrastructure, droughts serve as a trigger to famine.

Famines appear as short-term crises, but this study and a parallel one by IFPRI in Ethiopia show that they arise out of long-term developments in policy, economic strategy, and ecology. This calls for research, such as this study, on these long-term factors, not just research into the short-term aspects of crises.

The persistence of famine in Sudan in the 1990s shows that such long-term research has application to current situations and could be of great assistance to Sudan and to other countries in Sub-Saharan Africa with similar conditions. IFPRI hopes that policymakers will regard the research findings and the recommendations as valuable contributions to their endeavors to reduce and ultimately eliminate incidences of famine.

Just Faaland

Director General
October 1991

ACKNOWLEDGMENTS

This report is the result of research undertaken with the close collaboration and administrative support of the Ministry of Finance and Economic Planning of the Democratic Republic of Sudan. Access to information, advice, and logistical support was provided by Sheik el-Mak, Hashim el-Zein, and Leyla Omar el-Beshir of the ministry. The regional Ministries of Agriculture and Natural Resources, Finance and Economic Planning, and Animal Resources, the Department of Forestry, and the Agricultural Bank of Sudan (El Obeid branch) in Kordofan were very helpful partners. The Ministry of Health and Social Welfare, Nutrition Division, kindly provided original nutrition-survey data for further analysis. The Jebel Marra Rural Development Project in Darfur collaborated with us on analyzing survey data collected in the project area. Mohamed Babiker Ibrahim, Yisehac Yohannes, and Graciela Wiegand-Jahn contributed important background papers, and Detlev Puetz provided valuable research assistance in the nutrition analysis.

We also benefited particularly from interactions, comments, and careful reviews of earlier drafts by Hassan el-Sheik; Abdel Razik el-Bashir; Abdalla A. Abdalla; colleagues at the Department of Agricultural Economics and Rural Sociology, Shambat; Penny Nestel; Nurul Islam; Amartya Sen; Harold Alderman; Hannan Ezekiel; Rajul Pandya-Lorch; and anonymous reviewers.

We gratefully acknowledge financial contributions by the Ministry of Economic Cooperation of the Federal Republic of Germany and by the Rockefeller Foundation for this research.

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1

SUMMARY

Famine has persisted in Sudan through the 1980s and into the 1990s. Drought is one of its immediate causes and must be understood in a broad context if famine vulnerability is to be reduced with appropriate policy. This study asks, What are the determinants of famine in Sudan? What role does drought play? Who is affected? And further, What has the experience been with private action, including market and household responses, and with public action, including policies and programs to deal with the problem? Quantitative analyses in the study are based on household-level data specifically collected for this research in western Sudan, available data from other sources, and market- and sector-level information.

Periods of drought have occurred throughout the history of Sudan. In most cases these have been followed by famine and outbreaks of disease. The 1984-85 famine was the outcome of a long process of drought and desertification, absent or misplaced public food and agricultural policy, and insufficient public response. Lacking in the government's response were a permanent institution responsible for famine preparedness and the political will to intervene early to prevent large-scale hunger and mass movements. Emergency food aid, which largely followed official recognition of the existence of famine, was constrained by untimely availability and logistical and managerial limitations. In addition, the macroeconomic policy environment in the 1970s and 1980s was not conducive to preventing erosion of the country's capacity to deal with the drought crises. War and civil unrest further undermined such capacity.

A large drop in agricultural production occurred in 1984/85. This decline translated into a large drop in farm employment. A strong link between agricultural production and income (from crop production, local off-farm wage employment, and livestock) increased the extent of income failure. As shown by an IFPRI survey in the famine-prone area of Kordofan in western Sudan, a large drop in nominal income, coupled with a rapid rise in food prices, resulted in a severe and widespread decline in purchasing power. Farmers had to dispose of their animals to maintain their food entitlement and to avoid imminent loss through death of the animals. Asset-poor households had to depend greatly on nonagricultural products and transfers to augment their low income. Some farmers had to move out from their villages much earlier than the normal season in search of work or relief support. Given the large share of income spent on food, households had to adjust their food consumption by cutting the size and frequency of meals and by changing the composition of their diet.

The original survey information from western Sudan shows that farmers adopt multiple coping paths and responses that involve substitutions in production, income, assets, and consumption. Households vary in their emphasis on the choice of coping responses. In general, they try to avoid action that would endanger their future survival. Their success in coping, however, is unequal across households because of unequal income and asset bases and unequal access to community risk-sharing networks and public support. Famine strikes different socioeconomic groups in different ways. The evidence of 1984-85 shows that although the famine had a distinct location character, some groups were affected much more than others. Hardest hit were camel nomads in the northern arid zones, especially small-herd owners; asset-poor households, particularly recent settlers and capital-constrained female-headed households; and families without working members. The problem of recent settlers posed a special dilemma in light of the presence of a large number of war refugees in the area. In general, the burden of coping fell heavily on low-income households with a very small protective income source or asset base. The evidence also shows a rapid shift in the phases of and participation in the coping process that was adopted by the rural population in western Sudan, a severely affected famine area.

The study traces the effects of drought on production, markets, consumption, and nutrition, focusing on the 1984-85 famine, its origin and aftermaths. Related findings are briefly reviewed below. Rainfall levels have declined in Sudan during the past three decades: mean annual rainfall declined by 6.7 percent between 1960-69 and 1970-79 and by 17.7 percent between 1970-79 and 1980-86. Furthermore, year-to-year fluctuations in rainfall around a trend line seem to have increased, especially in arid and semi-arid zones. For example, coefficients of variation increased, on average, from 16 percent in the 1960s to 21 percent in the 1970s and 32 percent in the 1980s in western Sudan.

The decline in rainfall levels has resulted in low growth in cereal production, largely because of short-run effects on yield, as evident from a comparison of growth estimates with and without the drought year of 1984. Cereal production is also marked by considerable and increasing year-to-year fluctuation. Yield variability has been strongly associated with variability of rainfed crops.

Drought-production relationships show that a 10 percent drop in annual rainfall from mean levels implies a 5.0 percent drop in cereal production and a 3.7 percent drop in yield at the country level. Sorghum yield and, consequently, production are shown to be more affected than millet by declines in rainfall. A 10 percent drop in annual rainfall results in drops of 7.3 and 3.0 percent in sorghum and millet production, respectively.

Markets for cereals are thin and very responsive to production changes. Deflated (real) cereal prices increased more than three times in the main famine year of 1984-85 compared with 1982-83. The related time-series analysis in the study shows that, under the prevailing trade and market-structure conditions, a 10 percent drop in production led to an approximate 26 percent increase in real prices of cereals in the same year. A 10 percent reduction in stocks (calculated at mean values) increased prices by 8 percent. Trade and aid contributed little toward mitigating the price effects of the drought-driven production fluctuation.

The terms-of-trade change in disfavor of livestock and cash crops signals one element of the decline in the purchasing power of rural households. The terms of trade between domestic cereal and livestock changed drastically as a consequence of the drought in the 1980s. They increased from 1:1 in 1980 to about 1:8 or 1:10 in 1984-85. Thus, to acquire the same amount of cereals, 8 to 10 times more livestock had to be offered in 1984-85 than in 1980. The model analysis shows that a 10 percent drop in cereal production resulted in an 18 percent increase in the cereal and livestock terms of trade. Domestic terms of trade between cereals and cash crops, such as groundnuts and sesame, increased by 2 to 3 times as a consequence of the drought-related declines in cereal production. These combined production and price effects resulted in food-entitlement failure for large segments of the rural population.

Although considerable relative differences prevailed between regions, the general food price movement during the food crisis in 1984-85 spread all over the country, thereby spreading the burden of the crisis to the poor in nondrought and urban areas. A statistical model testing for market integration shows that food markets were not segmented and that there was strong transmission of prices. Though interregional commodity flows were hampered by high market-transaction costs, particularly transport costs, a situation of "market failure" during the food crisis was not observed. However, the dramatic changes in the domestic terms of trade could happen only because of the limited integration of the country into the international exchange economy. A less constrained administrative and foreign exchange situation, or more (timely) food aid, might have prevented some of the large movements in prices.

The growth of aggregate per capita food availability was negative in the 1970s and 1980s, largely because of low growth in production relative to population growth. In 1984, there was a particularly large drop in per capita food availability despite measures to mitigate consumption shortfalls, such as increased food aid, imports, and off-take from public grain reserves. The drop varied by region and the impact by type of household. Adjustment pressures to drought-induced price and income changes are much greater for the low-income households, particularly for those in drought-prone areas. This applies also to child nutritional welfare in these households.

The combined production and price effects translated into nutritional deterioration. Deficiencies in rural health services also played a key role in this context. As the recurrent drought had stripped many rural households of their asset base in the early 1980s, the main drought in 1984 immediately translated into a drastic nutrition problem. Many families were left with no ability to cope. Thus the observed parallel movement of prices and malnutrition on a month-by-month basis suggests that price information can be of only limited value as an indicator of "early" warning when the asset base is already deteriorated. It also calls attention to the need to prevent extreme price instability in the interest of child nutritional welfare.

Assessment of child nutritional status in the postfamine period of 1986-87, based on a large sample survey, shows a sizable presence of child undernutrition, with significant variations across regions, locations, and seasons. Child characteristics (such as sex and age), frequency and type of food intake, human capital endowment (that is, mother's education), health and sanitation environment, and incidence of disease are found to be important determinants of child malnutrition status. In addition, it is confirmed that cereal price increases not only significantly reduce household staple food consumption but also contribute to children's nutritional deterioration (weight-for-age). The combination of lack of food at the household level and acute diarrhea in children results in life-threatening nutritional deterioration of large proportions of preschool children. This analysis, stressing policy action for nutritional improvement, requires that food availability, employment, and community health and sanitation be addressed simultaneously.

The 1984-85 crisis uprooted large segments of the rural population and resulted in depletion of their assets and in stress migration into urban areas. Future food price explosions (in the context of another drought) will hit these people even more as wage earners without degrees of freedom to cope.

The evidence of the 1984-85 famine confirms that drought is a major determining factor in famine in Sudan. Decline in the level of rainfall and its increased variability substantially undercut the food entitlement of large segments of the population through production and employment effects. The risk increased during the 1980s because of continued low and variable production, slow recovery in the asset base, permanent out-migration, and increased dependency on volatile rural markets. In fact, the new dynamics of famine make it much more difficult to identify and trace vulnerable groups on a continuous basis for policy targeting.

The microhousehold and community-level effects of specific projects and programs aimed at reducing famine are reviewed on the basis of original survey information. This includes an assessment of food aid and relief management in Kordofan, asset-rebuilding programs (including both food for tree-planting and livestock restocking), and agricultural-technology dissemination (in Darfur). In conclusion, from these project experiences, the critical role of sustainable food production in the rainfed sector of Sudan is emphasized. The key components of such a strategy include improvement of resource conservation and management, development and dissemination of labor-augmenting technology, and promotion of human and physical infrastructure as well as institutional capacity. Relief and rehabilitation are necessary integrants of the whole development process.

Based on a review of past policies and problems, the study emphasizes a set of general policy priorities for famine prevention that includes political stability, that is, an end to wars; participation of the rural population, especially through decentralization, in relief and rehabilitation; macroeconomic policy reforms, especially of exchange rate and pricing policies, and the control of inflation.

The specific policy priorities for famine prevention derived from the quantitative analysis include (1) promotion of sustainable growth in the traditional rainfed agriculture through expansion of rural infrastructure; provision of labor-intensive public works programs; input supply, with scope for private-sector involvement; adaptive research, technology, and extension; and protection of the environment; and (2) emergency preparedness and relief with buffer stocks for price stabilization, improved relief management and early warning systems, strengthening of rural health and sanitation, and comprehensive legislation for famine prevention.

2

FAMINE DEBATE, CONCEPTUAL FRAMEWORK, AND STUDY APPROACH

The Research Questions

Sudan has been hit hard by the droughts in the 1970s and 1980s. Loss of the resource base of households, especially in the west and northeast, has led to serious economic deprivation. The 1984-85 famine is a recent case in point. This study acknowledges the important and disturbing role of the long-lasting armed conflict in southern Sudan in undermining the economic and institutional base of the country and thereby increasing overall famine vulnerability. The regional focus of the study is, however, on the western and northern provinces of the country.

Understanding these problems requires a properly conceived framework to examine the factors contributing to the process of recurring severe food shortages and entitlement failures. A brief overview of the ongoing debate on the causes of the 1984-85 famine is juxtaposed here with a conceptual framework. Past policy failures have created the environment that now makes drought a central cause of famine crises and persistent hunger in large parts of Sudan. This point will be discussed in Chapter 7 within an overview of the "disenabling" economic policy environment in Sudan during the past three decades.

While focusing on drought, the study begins with the hypothesis that famine in Sudan is the result of interactions of various determinants. Drought is one of these, but to stimulate an appropriate policy response that will reduce the famine vulnerability of the people, it must be understood in a broad context. The research questions of this study are, What are the determinants of famine in Sudan? What role does drought play? Who is affected? And what has been the experience with private coping responses, including market and household reactions, and with public action, including policies and programs for dealing with the famine problem?

The Debate on Causes of the 1984-85 Famine

Studies on the 1984-85 famine in Sudan converge on two key facets. First, famine is an outcome of a long process. The main contributing components are drought and desertification (Ibrahim 1984; Ibrahim 1985; ILO 1985; IES 1986), lack of or misguided government food and agricultural policies (Abdel Ati 1988), and absence of institutional capacity and political will to respond effectively to famine and economic crises (Shepherd 1988). Second, the outcome of such a process is often articulated in declining regional (but not necessarily national) food availability, which, because of extreme infrastructural deficiencies, results in mass starvation and excess deaths due to hunger and diseases.

A large-scale decline in food availability is considered central to an explanation of widespread food shortages and starvation in Sudan, but not in general as a cause of famine (Drèze and Sen 1990). By 1981/82 the cereal food balance in Darfur had dropped by 23 percent from its 1971/72 level, and in 1983 there was a deficit of 76 percent of the sorghum requirements in Kordofan (ILO 1985). El-Sammani points out that in 1984 the food gap was 80 percent of the total cereal requirement in Kordofan (IES 1986). In the case of pastoralists, who depend mainly on livestock, the effects of famine were often transmitted through loss of livestock and deterioration of terms of trade (ILO 1985).

Desertification (loss of productive land) is itself an outcome of natural and human actions. The desertification process has intensified since the beginning of the dry cycle of 1968 because of a declining pattern of precipitation, a southward shift of the rainfall belt, increased variability of rainfall, and enhanced human activities such as overcultivation, overgrazing, woodcutting, and deforestation. The process was exacerbated in the early 1980s by the occurrence of consecutive droughts that caused the deterioration of rangelands and a large drop in land productivity. The great famine of 1984-85, according to those who ascribe famine to ecological imbalance, was the outcome of a long process of desertification intensified by years of droughts.

The famine of 1984-85 has also been ascribed to faulty agricultural policy. Central to this argument is that the pursuit of "modernization" of the agricultural sector, which often meant the promotion of large-scale, capital-intensive technology in high-potential areas, has contributed to the neglect of the smallholder traditional crop and livestock sectors and a deterioration of the ecological balance. The neglect of traditional smallholders, which is marked by low levels of their food production and income base, means a low level of preparedness on the part of the farm population to survive consecutive seasons of crop failures. In the case of the 1984-85 famine, because of low and variable income, farmers were ill-prepared in terms of generating or accessing their staple foods, especially in the western regions of Darfur and Kordofan and in Eastern Region.

The government's ineffective response to protecting these rural populations in 1984-85 was also considered a contributing factor to the resulting large-scale starvation and deaths (Shepherd 1988). Lack of a permanent institution responsible for famine preparedness and response, absence of a famine policy, failure to invoke the famine codes of 1920, slow official recognition of the risky situation, and late intervention were characteristics of the situation in 1984-85. There were limited and ad hoc responses, but they were not sufficient to avert or minimize the crisis.

The writings on Sudan point out that even though the famine of 1984-85 was nationwide, it was more concentrated in the arid and semi-arid areas of the western and eastern regions. These areas are characterized by ongoing desertification intensified by consecutive droughts, highly variable seasonal food production, an undeveloped infrastructure base, and neglect on the part of the government in enhancing and shielding the income capacity of the population. In addition, these regions have been identified as the areas of highest population increase (after Khartoum and Upper Nile) in the 1973-83 period (ILO 1985).

The causes of famine suggested by these writers largely fit into the profile of African countries that fail to enhance and protect the income-generating capacity of their most vulnerable population in times of crisis (Drèze 1989). The search for an in-depth understanding of these causes is the primary component of the present study. This pursuit is undertaken in a framework that makes the entitlement approach (Sen 1981) central to understanding the causes of and ability to cope with crises. However, great importance is also attached to the food production and supply dimensions as key variables in explaining the relationships between the production-employment-income-consumption components in the African context (Mellor and Gavian 1987), particularly in Sudan. As will be shown, food production and food entitlement failures are very closely linked in Sudan. It will be argued that strengthening food entitlements has to be brought about to a large extent—but not only—by expanding agricultural growth in the Sudan through employment generation and increased food supply.

Conceptual Framework

A clear distinction needs to be made between hunger (including seasonal hunger), undernutrition, and famine.

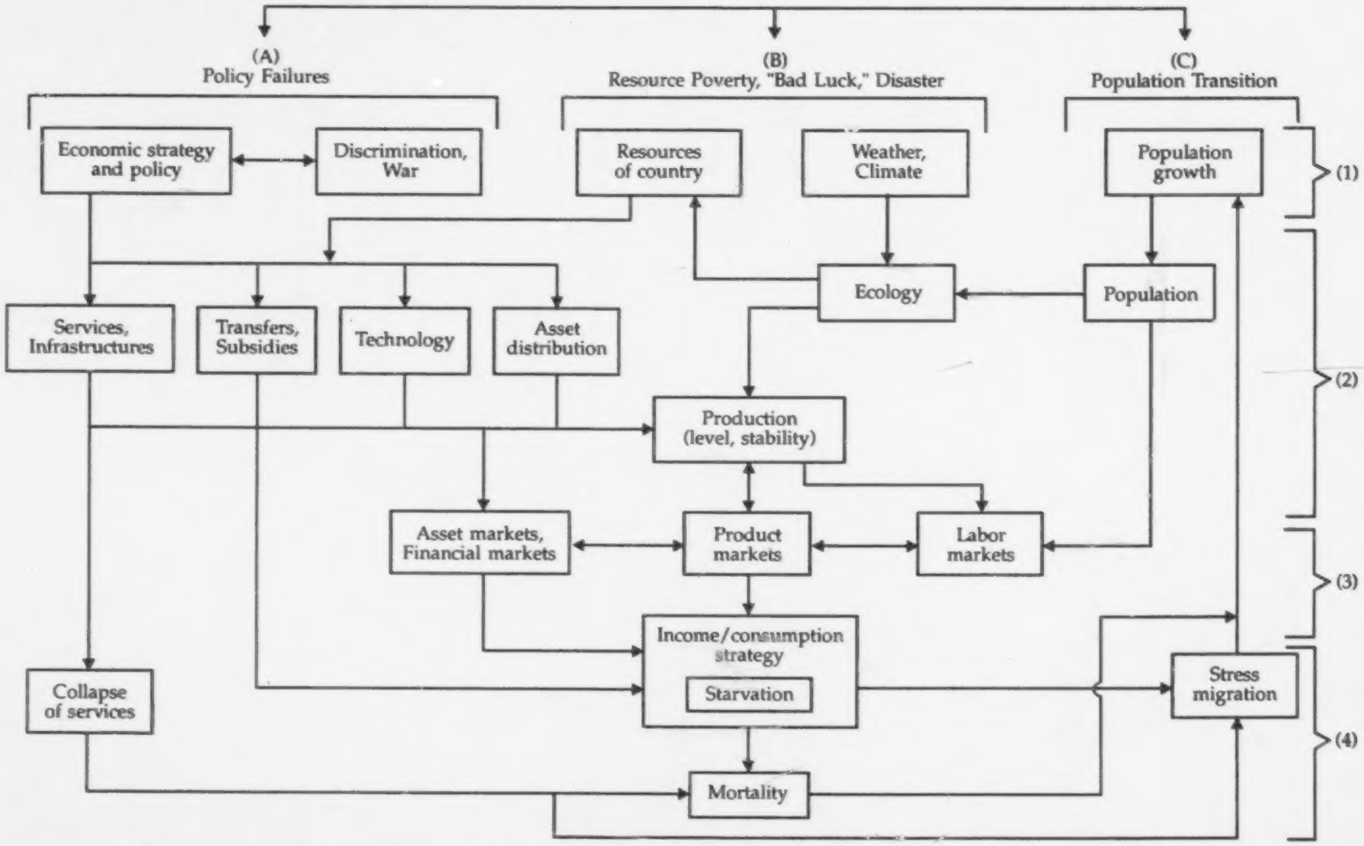
Hunger—largely an advocacy rather than a scientific term—is defined here as not having enough to eat to lead a healthy and active life. It is a recurring feature of the absolute poor, especially in developing countries. In connection with the above, seasonal hunger is often associated with the population in rural areas, where it occurs during the preharvest season when food stocks of the rural poor are depleted and the affected population can ill afford to purchase food because of related higher seasonal prices.

Undernutrition is due to a deficient intake of specific nutrients in a diet. It can lead to illness (lack of energy, retardation, or blindness, for instance) or even death, although the symptoms may not be recognized as indications of nutrient deficiencies. Interactions between undernutrition and illness are particularly complex.

Famine is the presence in a specific area or country of widespread and extreme hunger that results in drastic loss of body weight and a rising death rate. The causes may be shortages in food availability or inaccessibility of available food due to drought, flood, political (war) or economic disruptions, or massive income declines brought about by factor or product market disruptions. Most frequently, famines are a result of complex combinations of some of these causes. Famines are mainly a rural feature and occur in areas where chronic undernutrition is often observed.

A root cause of famine is poverty, including the associated vulnerability to disaster. Yet poverty may be seen as an endogenous outcome of resources and policies. Figure 1 is an attempt to delineate relationships between root causes and symptoms of famine events in a rough sketch. Endogenous and exogenous relationships are conceptualized at different levels of analysis. The broad interactions between policy failures; resource poverty, "bad luck," and disaster; and the population transition process are depicted. Cause-and-effect relationships are then distinguished with some of the more important nonexhaustive indications of feedback mechanisms between the four levels of analysis: (1) the top layer comprises the level of economic strategy and policy interacting with discrimination, social conflicts, and wars; resource endowments of the country and their relationship to climate or disaster events influencing levels of poverty and instability of the (food) system; and population growth. Little comprehensive research exists in Africa on

Figure 1—Determinants of and relationships in famines


(A)
Policy Failures
(B)
Resource Poverty, "Bad Luck," Disaster
(C)
Population Transition
Economic strategy and policy
Discrimination, War
Resources of country
Weather, Climate
Population growth
(1)
Ecology
Population
Services, Infrastructures
Transfers, Subsidies
Technology
Asset distribution
(2)
Production (level, stability)
Asset markets, Financial markets
Product markets
Labor markets
(3)
Income/consumption strategy
Starvation
Collapse of services
Stress migration
(4)
Mortality

Note: (A), (B), and (C) are interrelated clusters of causes; (1), (2), (3), and (4) are levels of analysis.

the interactions between these three basic clusters in constituting famine events—for instance, the political economy of hunger and endogenous population growth; (2) the second layer contains policy interventions (such as subsidies, distributional policies, and the investment portfolio) that influence the input/output relationships (production levels and stability); (3) policy interventions interact with the price formation and interlinkages in capital, labor, and output markets depicted in the third layer; and (4) the last layer of assessment of famine consequences relates to the actual observation of income and consumption failures and the resulting starvation and excess mortality interacting with the collapse of services and stress migration.

Famine outcomes are an indication of a failure of the coping process that is observed at household and individual levels. Figure 2 provides a simplified anatomy of a household economy linked to outcomes determined at layers (1), (2), and (3) in Figure 1. In addition, it shows a pattern of responses at the household level and sources of variation in household capacity to respond to crisis.

Figure 2 represents a typical case of a sedentary farm household. A great proportion of its resources, land and labor in particular, goes into crop production. In addition, part of the family labor is switched to generate income from other sources to supplement crop income. Household income at any particular point in time is a combined outcome of these income sources. Exogenous changes in climate, market prices, and public policies (outcomes in Figure 1) influence the level as well as the sources of household income. Income generated from these sources is translated into consumption and asset accumulation. Food consumption is presumed to affect household nutritional status, which in turn influences the incidence of morbidity and mortality in interaction with the sanitary and health environment. Part of the income that is saved is often invested in livestock to ensure continuity as well as protection of future income flow.

Various paths of adjustments open to the household are displayed in Figure 2: production, labor (migration), asset, transfer (individual, community, or public), and consumption paths. A large drop in crop production is likely to subject a household to severe stress because of strong production-income-consumption links. However, a production shortfall should not necessarily be translated into much-reduced food intake if other paths of adjustment prevent income and consumption failures. Of course, the relative importance of these paths shifts, depending on the source, persistence, and phase of the process that has triggered the food distress.

The simple structure in Figure 2 does not capture variations in a household's demographic life cycle and entitlement endowment (level of skill and experience, access to resources, accumulation of assets, and access to steady outside-income sources). These differences contribute variation in the choice of responses and success of coping. Households with low income, particularly those that are mainly exposed to high-risk income and have few income and asset sources, are at high risk. The burden of coping falls on these households unless community or public support reinforces their coping devices.

Overview of the Study Approach

The middle path in Figure 1 especially traces the drought-famine link pursued in this report. In Figure 3, this key path is isolated, and the types of interventions

Figure 2—Paths of household response to declining food entitlement

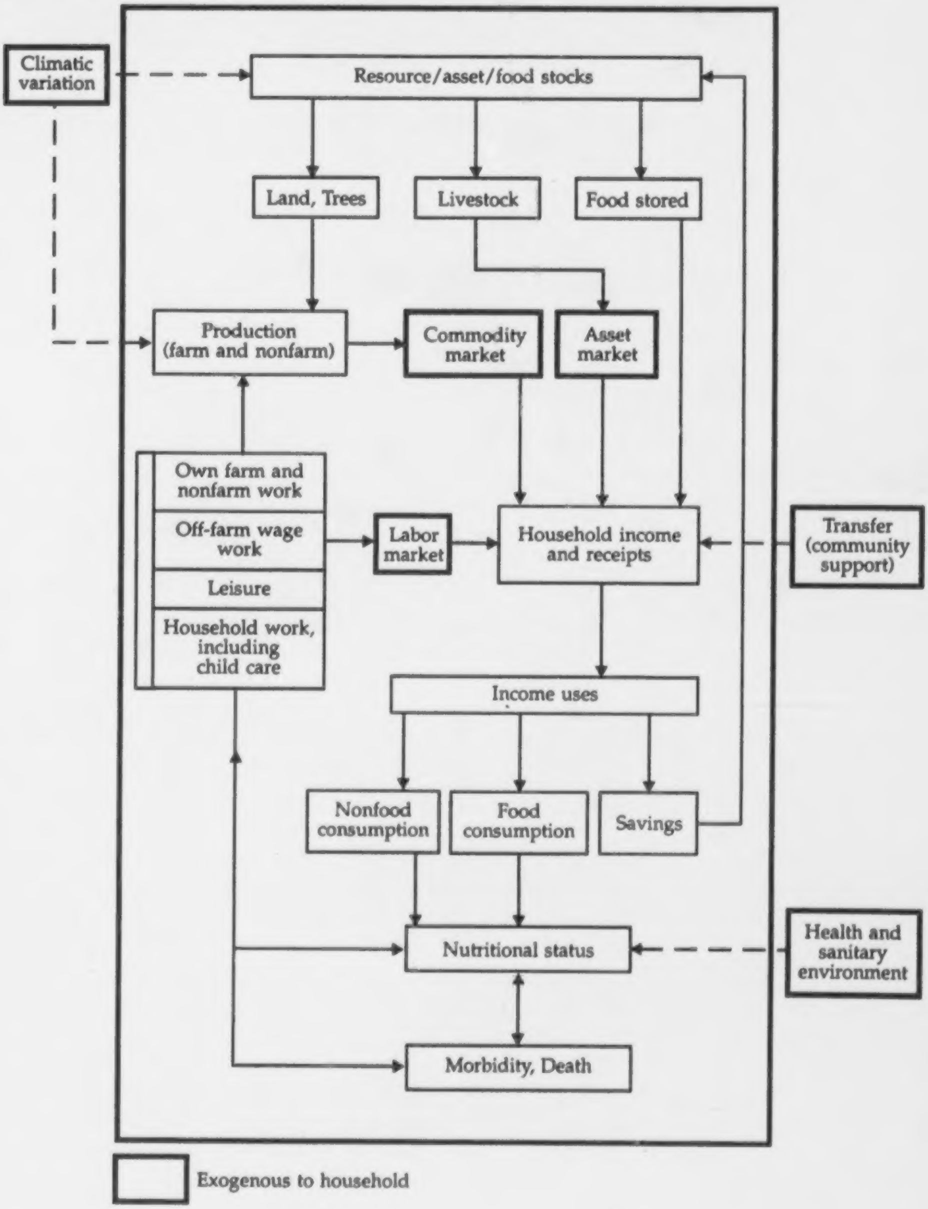
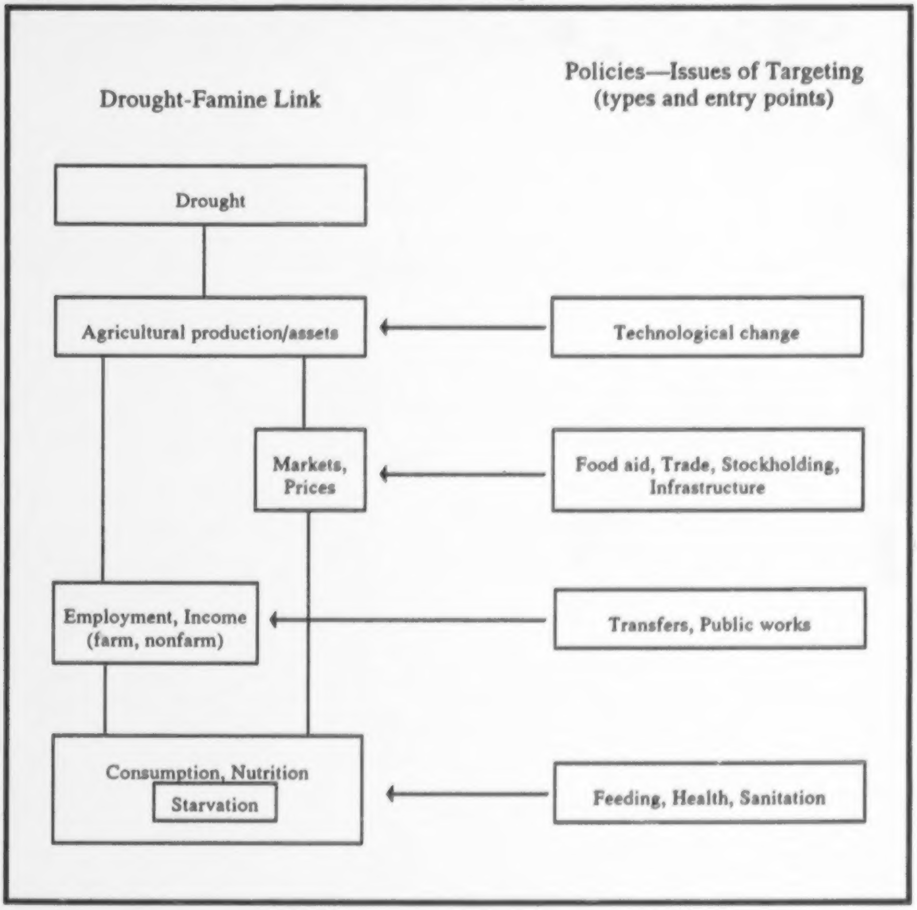

Climatic variation
Resource/asset/food stocks
Land, Trees
Livestock
Food stored
Production (farm and nonfarm)
Commodity market
Asset market
Own farm and nonfarm work
Off-farm wage work
Leisure
Household work, including child care
Labor market
Household income and receipts
Transfer (community support)
Income uses
Nonfood consumption
Food consumption
Savings
Nutritional status
Health and sanitary environment
Morbidity, Death
Exogenous to household

Figure 3—Overview of the focus of the analysis


Drought-Famine Link
Policies—Issues of Targeting (types and entry points)
Drought
Agricultural production/assets
Technological change
Markets, Prices
Food aid, Trade, Stockholding, Infrastructure
Employment, Income (farm, nonfarm)
Transfers, Public works
Consumption, Nutrition
Starvation
Feeding, Health, Sanitation

that could be targeted at the various points of the drought-famine chain are identified. The principal relationships may be thought of as a set of recursive systems of equations defined as

$$Q = Q(W, P, Z_1, U_1) \quad \text{production response,} \quad (1)$$

$$P = P(Q, Z_2, U_2) \quad \text{short-term price response, and} \quad (2)$$

$$C = C(P, Y(Q), Z_3, U_3) \quad \text{consumption response,} \quad (3)$$

where

Q = production index,
P = price index,
C = consumption index,

W = weather index,
Y = income index,
Z_1 = nonweather and nonprice shifters,
Z_2 = nonproduction-related shifters,
Z_3 = nonprice and nonincome shifters, and
U_1, U_2, U_3 = error terms associated with production, price, and consumption equations.

It is obvious that complex trade-offs prevail between the indicated types of interventions in the short run and long run.

The presentation of the report follows the structure depicted in Figure 3. An overview of the record of drought and famine in Sudan's history is introduced in Chapter 3. It focuses especially on household and village experiences, based on IFPRI surveys and other primary data. The experience of the 1984-85 famine is highlighted with a discussion of its nature and effects and of the responses in the drought region of western Sudan. This is followed by a review of the development of agricultural production and a model relating rainfall to production at different levels of commodity and regional disaggregation. The impact of the 1984 drought is isolated to demonstrate the production effects of drought (Chapter 4). The behavior of prices and markets in a context of production shortfalls and famine in an environment of extremely weak interregional trade infrastructure is the focus of Chapter 5. The transitory food security problem (famine) grows rapidly out of the massive chronic food security and undernutrition problems. The effects of changes in prices and income on nutrient consumption are traced in Chapter 6. An assessment of the nutritional situation in the postfamine period shows the prevalence of undernutrition in the presence of inadequate food intake, poor community and health infrastructure, and low levels of human capital. Chapter 7 reviews past economic and famine policies—or the lack thereof—and draws lessons from the experience gained in coping with food crises in the 1980s through food aid and specific projects, again drawing mainly on original household-level survey information. Finally, conclusions are drawn regarding policy options that would be effective in coping with the adverse effects of drought, on both short- and long-term bases, to prevent drought from being a trigger for famine.

3

RECORD OF DROUGHT AND HOUSEHOLD-LEVEL CONSEQUENCES IN WESTERN SUDAN

The Historical Record

Drought and its consequences are historical as well as contemporary problems in Sudan. A careful review of the literature by Ibrahim (1985) shows that periods of drought have occurred throughout the history of Sudan, and in most cases these have been followed by famines and outbreaks of disease.[1]

An overview of droughts and related famines in the country is provided in Table 1. The earliest recorded famine occurred in 1684. The 1835-38 period is known as the "years of famine," particularly the year 1836, which is notable for widespread cholera that decimated a population already weakened by hunger (Hill 1970). The 1888-89 famine is considered to be the greatest famine, caused by two consecutive years of poor rains (Slatin Pasha 1896; Churchill 1899; Duncan 1952; Farwell 1967; Holt 1970) and by political instability and unrest. Hundreds of thousands of people died of hunger and disease. Rain was abundant the following year, but harvests were destroyed by locusts and other pests. The year 1913 also witnessed poor rains, but major famine was averted by importing corn and distributing it free (MacMichael 1934).

These records indicate diversity in the spatial incidence of drought and famine, with frequent occurrences concentrated in the western and eastern regions (Figure 4). A paucity of information and unbalanced documentation of historical events may be responsible for showing less frequency of drought in the western part of the country. In 1983, aware of these facts, Ibrahim (1985) investigated the drought experience of western Sudan. He relied on the memories of farmers, meteorological records, and fragmentary historical records to identify years of drought and famine. Farmers identified 36 years as years of drought and famine in the period between 1912 and 1974—26 years in eastern Kordofan and 18 years in eastern Darfur. Eight of these years were common to both areas. Seventeen of these years were given local names to describe sources of survival, scarcity of necessities, and magnitude of hardships. Fifty percent of these perceived periods of drought were meteorologically confirmed, with rainfall well below average. Records of rainfall failed to recognize the other years, perhaps, according to Ibrahim, because of the nature of rainfall in the semi-arid areas where rain is highly localized or because the recall of events by local inhabitants may be faulty.

Ibrahim's findings concur with historical records that 1913, 1914, and 1927 were drought years (Table 1), but these droughts actually spread from the eastern

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[1] This chapter draws heavily on contributions of Mohamed Babiker Ibrahim (1985, 1990).

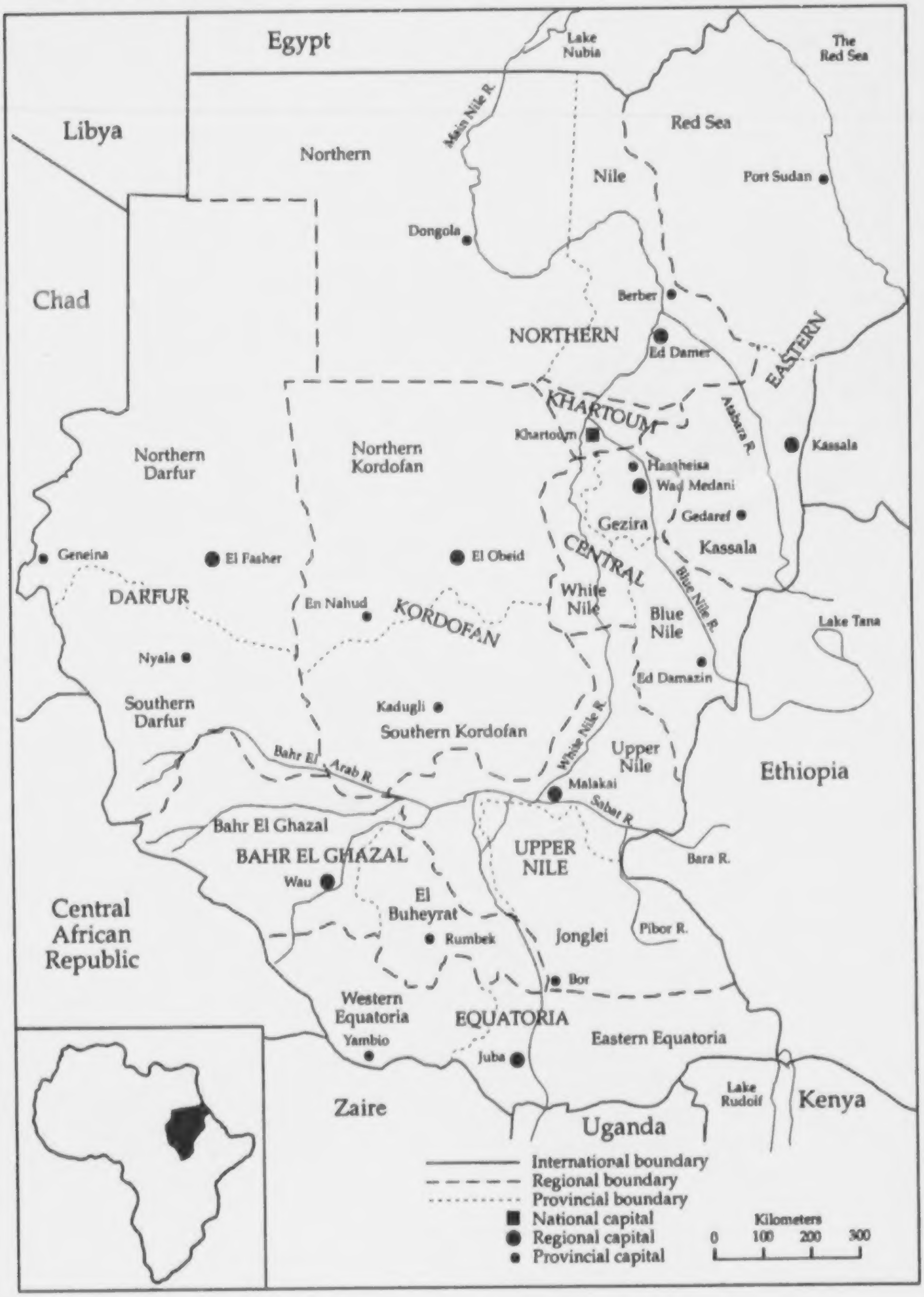
Table 1—Years of famine and drought in Sudan reported by historians

Years of Drought or Famine	Name and Damage	Areal Extent	Source
1684	"The great famine" *(Um Lahm)*	Sinnar region	O'Fahey and Spaulding (1974)
1835-38	"Years of famine"	Central Sudan	Hill (1970)
1836	Cholera spread through country	Central Sudan	Hill (1970)
1885	Slight famine	Central and eastern Sudan	al-Gudal (1983)
1888-89	Hundreds of thousands died	Central, northern, eastern, and western Sudan	Slatin Pasha (1896)
1888-89	No rain for a year, crops failed and grain became increasingly scarce. Prices rose to US$40 and then to US$60 for two sacks of dura (sorghum). People sold their children as slaves to save their lives and later bought them back with higher prices.	Central, northern, and eastern Sudan	Duncan (1952) Farwell (1967) Churchill (1899) Holt (1970)
1888-89	Thousands died of hunger and disease	Central, northern, eastern, and western Sudan	MacMichael (1934)
1890	Locusts and mice consumed the products	The Nile area	Farwell (1967) Duncan (1952)
1913	Poor rain, corn brought from India and issued free of charge in distressed areas and cheaply elsewhere	Mainly northern Sudan	MacMichael (1934)
1914	"The year of the flour" (flour brought from India because of poor rains)	Central Sudan	Henderson (1965)
1927	Slight famine	Central and eastern Sudan	al-Gudal (1983)

Source: Based on data from Mohamed Babiker Ibrahim, "Adjustment to Drought Hazard in the Semi-Arid Areas of the Sudan" (Ph.D. diss., University of Alberta, Edmonton, Alberta, Canada, 1985).

border of Sudan westward to Kordofan and Darfur regions. Moreover, Ibrahim added 1935, 1937, 1942, 1949, 1951, and 1957 as years of severe drought in Sudan. Shepherd (1988) identified 1932, 1938, and 1949 as years of severe famine through investigation of famine files for the period between 1932 and 1950. Combining these two sources, one would speculate that 1913-14, 1927, 1932-34, 1937-38, 1942, and 1949 were the years of most severe localized or nationwide famine in the country in this century up to the end of the 1950s. Occurrences of severe famine were fewer in the 1960s and 1970s, except for 1966, when famine was reported by farmers in the west. Of course, there could have been numerous unnoticed localized famines. Sudan largely escaped the worst years of the Sahelian drought of 1968-73 but experienced a major drought-related famine in 1984-85—about 100 years after the major drought of 1888-89.

Figure 4—Map of Sudan


Egypt
Lake Nubia
The Red Sea
Libya
Northern
Main Nile R.
Red Sea
Nile
Port Sudan
Dongola
Chad
Berber
NORTHERN
Ed Damer
EASTERN
KHARTOUM
Khartoum
Atbara R.
Kassala
Northern Darfur
Northern Kordofan
Hassheisa
Wad Medani
Gezira
Gedaref
Kassala
Geneina
El Fasher
El Obeid
CENTRAL
DARFUR
En Nahud
KORDOFAN
White Nile
Blue Nile
Blue Nile R.
Lake Tana
Nyala
Ed Damazin
Southern Darfur
Kadugli
Southern Kordofan
White Nile R.
Upper Nile
Ethiopia
Bahr El Arab R.
Malakai
Sobat R.
Bahr El Ghazal
BAHR EL GHAZAL
UPPER NILE
Bara R.
Wau
El Buheyrat
Rumbek
Jonglei
Pibor R.
Central African Republic
Bor
Western Equatoria
EQUATORIA
Eastern Equatoria
Yambio
Juba
Lake Rudolf
Kenya
Zaire
Uganda
International boundary
Regional boundary
Provincial boundary
National capital
Regional capital
Provincial capital
Kilometers
0
100
200
300

Ibrahim also pointed out that drought and hunger are generally closely related in the western provinces, but the relationship is not a constant and necessary one. Failure of rains had nothing to do with the remembered food shortages in 1929, 1945, 1950, and 1959, which consistently show up in household-level surveys but do not coincide with actual rainfall information from the very same locations. Ibrahim suspects that it is probable that these food-shortage situations were due to insects, locusts, rodents, or plant diseases, or that local people were subjected to some kind of grain scarcity for social, administrative, or political reasons.

The Experience of Drought in the 1980s

The severe drought of 1984 was the culmination of a prolonged period of low rainfall that intensified after the end of the 1970s. According to Nicholson (1985), rainfall deficits for 1981 through 1984 equal or exceed those of the early 1970s in all Sahelo-Saharan, Sahel, and Sudan zones. Hulme (1984) also concluded, on the basis of observed rainfall data in the arid zone of Sudan, that the years from 1979 to 1983 were as dry as 1969-73. Recent findings (Eldredge et al. 1987) on western Sudan reveal that dry conditions have persisted in Northern Kordofan and Northern Darfur provinces since 1966. The authors attribute the downward pattern in annual precipitation to a decline in rainfall in July, August, and September—months that account for not less than 90 percent of annual rainfall. Moreover, they ascribe the decline in these months largely to fewer rainy days.

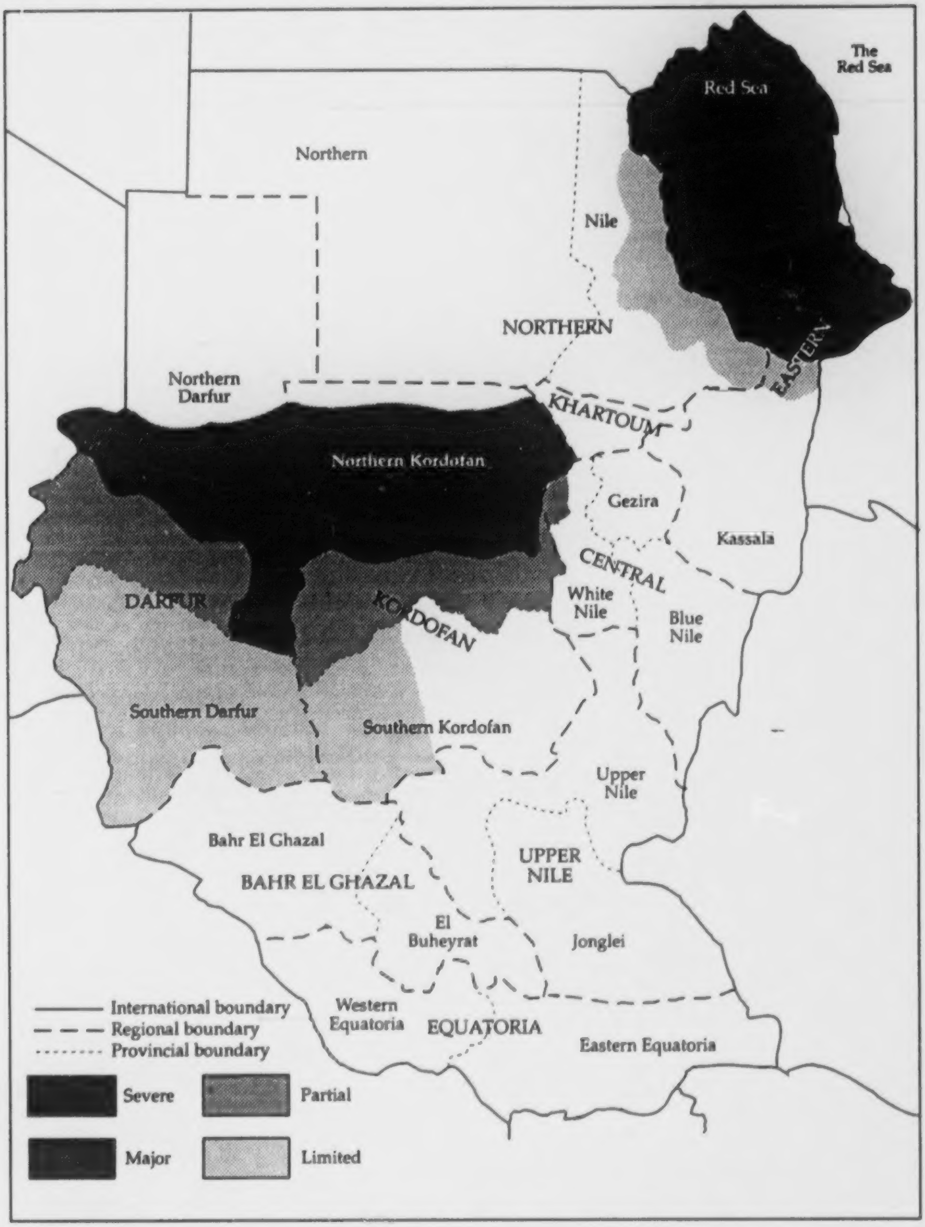
Information at the local level illustrates the development of dry conditions. According to a 1983 field survey, farmers and nomads in eastern Kordofan pointed out that the years between 1979 and 1983 were drought years (Ibrahim 1985). Households that migrated from Northern Kordofan and settled around Omdurman identified the period of 1980-84 as a severe dry period (Khalil 1987). The 1984 drought was the peak of the process that was set in motion in the late 1970s.

The main area affected by drought and desertification in Sudan is above 12° north latitude (Figure 5). In August 1984 Kordofan and Darfur had 2.8 million and 1.4 million, respectively, classified as affected population (Table 2). Of this affected population, those who lived above 13° north latitude were considered as severely affected. This group comprised 1.2 million in Kordofan and 0.8 million in Darfur. The reports of the United Nations Emergency Operation office for 1985 and early 1986 classified those at nutritional risk as vulnerable groups, especially pregnant and lactating women, and children under five years of age (OXFAM-UNICEF and Kordofan 1985a, 1985b, 1985c, 1986). These groups were estimated at more than 700,000 in Kordofan and about 800,000 in Darfur by mid-1985 (Pearson 1986).

Data on the magnitude of the displaced population are patchy. Available fragmentary information, however, indicates sizable displacements. By 1984, the population that had settled in the four major camps around Omdurman was estimated at 46,000 (Economic and Social Research Council 1988). Those camped on the outskirts of El Obeid were estimated at 45,000 by March 1985. There were an estimated 25,000 people living in the camps on the outskirts of Kosti by June 1985.

The agricultural households experienced large-scale erosion in their traditional income base, with few employment opportunities outside the rural economy.

Figure 5—Map of areas of chronic food insecurity in the mid-1980s, Sudan


The Red Sea
Red Sea
Northern
Nile
NORTHERN
EASTERN
Northern Darfur
KHARTOUM
Northern Kordofan
Gezira
Kassala
CENTRAL
DARFUR
KORDOFAN
White Nile
Blue Nile
Southern Darfur
Southern Kordofan
Upper Nile
Bahr El Ghazal
UPPER NILE
BAHR EL GHAZAL
El Buheyrat
Jonglei
International boundary
Regional boundary
Provincial boundary
Western Equatoria
EQUATORIA
Eastern Equatoria
Severe
Partial
Major
Limited

Source: Based on a map received by the authors from the World Food Programme, Khartoum.

Note: Mapping of population groups by severity of food insecurity is based on a combination of ecological variation and measure of food gap by area.

Table 2—Estimates of drought-affected population in western Sudan, 1984-86

Region/Period	Affected Population[a]	Vulnerable Population[b]
	(thousands)	
Kordofan		
August 1984	2,819	1,168
November 1984	c	1,268
June 1985	2,830[d]	741[e]
February 1986	1,889[e]	. . .
Darfur		
August 1984	1,430	763
November 1984	c	763
June 1985	2,870[d]	752[e]
February 1986	1,212[d]	c

Source: Based on data from Roger Pearson, "Lessons from Famine in Sudan (1984-86)" (United Nations International Children's Emergency Fund, Khartoum, 1986, mimeo).

[a] Population that lived between 12° and 18° north latitudes.

[b] Population that lived above 13° north latitude.

[c] No information available.

[d] No definition of "affected" or "vulnerable" reported.

[e] Population at nutritional risk.

Large-scale entitlement failure occurred despite continuous adjustments on the part of the population to stabilize their production, income, and consumption. In extreme cases, some segments of the population became destitute and moved out from their villages en masse (de Waal 1987; KRMFEP 1986; Mohammed 1988).

The effects of the years of drought in the early 1980s also had far-reaching consequences on the ecosystem of the region. The continuous aridity, which was marked by a decline in the water table and low vegetation cover, intensified the process of desertification. The process was further exacerbated by human responses to the changing environment as farmers continued expansion of cultivation into marginal and fragile areas to make up declines in yields and resorted to generating income from the sale of tree crops to support their falling income (Ibrahim 1985).

The Case of Western Sudan

The western part of Sudan lies approximately between 08° 40′ and 20° north latitudes and between 22° and 32° 25′ east longitudes. The area north of 16° north latitude represents desert. The area between 14° and 16° north latitudes is semidesert. South of the semidesert, between 12° and 14° north latitudes, lies the Sahelian zone. The Sahel includes most of the region's agricultural population, who depend for their income on livestock and crop production. The Sudanic zone lies south of 12° north latitude.

The amount of rainfall decreases northward until it reaches the desert zone. Average annual rainfall is less than 100 millimeters in the desert. Mean rainfall ranges from 100 to 200 millimeters per year in the semidesert. North of the Sahel, where it is arid for 9-10 months, mean rainfall ranges from 200 to 400 millimeters a year. Annual precipitation ranges from 400 to 600 millimeters on average along the southern frontier of the Sahel. The latitudinal pattern of rainfall is modified by the existence of the Jebel Marra Highlands in Darfur.

The soils are sandy in the semidesert. They are more stabilized in the northern part of the Sahel—the *goz* belt. The soils become sandy loam in the middle and clay in the south. The alluvial wadi soils range from small pockets in the north to larger areas southward. The area around Jebel Marra is intersected by numerous seasonal streams and relatively rich wadi soils. These seasonal streams are used for cultivation and water harvesting, especially during drought years.

The northern parts of Darfur and Kordofan represent areas typical of arid and semi-arid zones. Population is sparse but relatively dense in areas with easy access to better soils and water points. Agricultural production potentials are continuously depleted due to ongoing desertification, which has been exacerbated by recurrent droughts (Ibrahim 1984). The poor resource base and low technology utilization contribute to low productivity. Undeveloped infrastructure, particularly transport systems, limits opportunities for integration into the larger but weak market economy (Swift and Grey 1989; Darfur Regional Government 1988).

Effects of Droughts in the 1980s

Western Sudan, particularly the northern part, experienced extremely low rainfall in the years between 1982 and 1984, with a record low in 1984 (see, for example, Figure 6). The effects of these drought years precipitated a large drop in agricultural production and income. Dramatic deterioration in economic conditions resulted in a severe and widespread decline in purchasing power, collapse in the asset base, large and unseasonal migration, and deterioration of nutritional status in 1984-85. Failure to generate or gain access to food, coupled with poor access to health facilities, contributed to increased morbidity and mortality rates in 1985.

Crop Production. Between 1982 and 1984, production of major crops (millet, sorghum, sesame, and groundnuts) declined sharply. The regional data for Northern Kordofan show a record low production in the 1984 crop year. Production of millet and sesame (the two most important crops in Northern Kordofan) reached lows of 14 and 10 percent, respectively, in 1984 relative to the 1974-81 level (Table 3). The drop in production was largely associated with the continuous decline in yield. Village-based studies in Northern Kordofan indicate the occurrence of severe crop failure in the drier northern areas. Ibrahim (1985) noted that crop yields were severely affected in the northern semidesert zone. Mohammed (1988) noted that there was a total crop failure in 20 villages in eastern Kordofan in 1984/85. An IFPRI survey in Kordofan villages shows sizable crop failure, even in the middle Sahelian zone (Table 4).[2]

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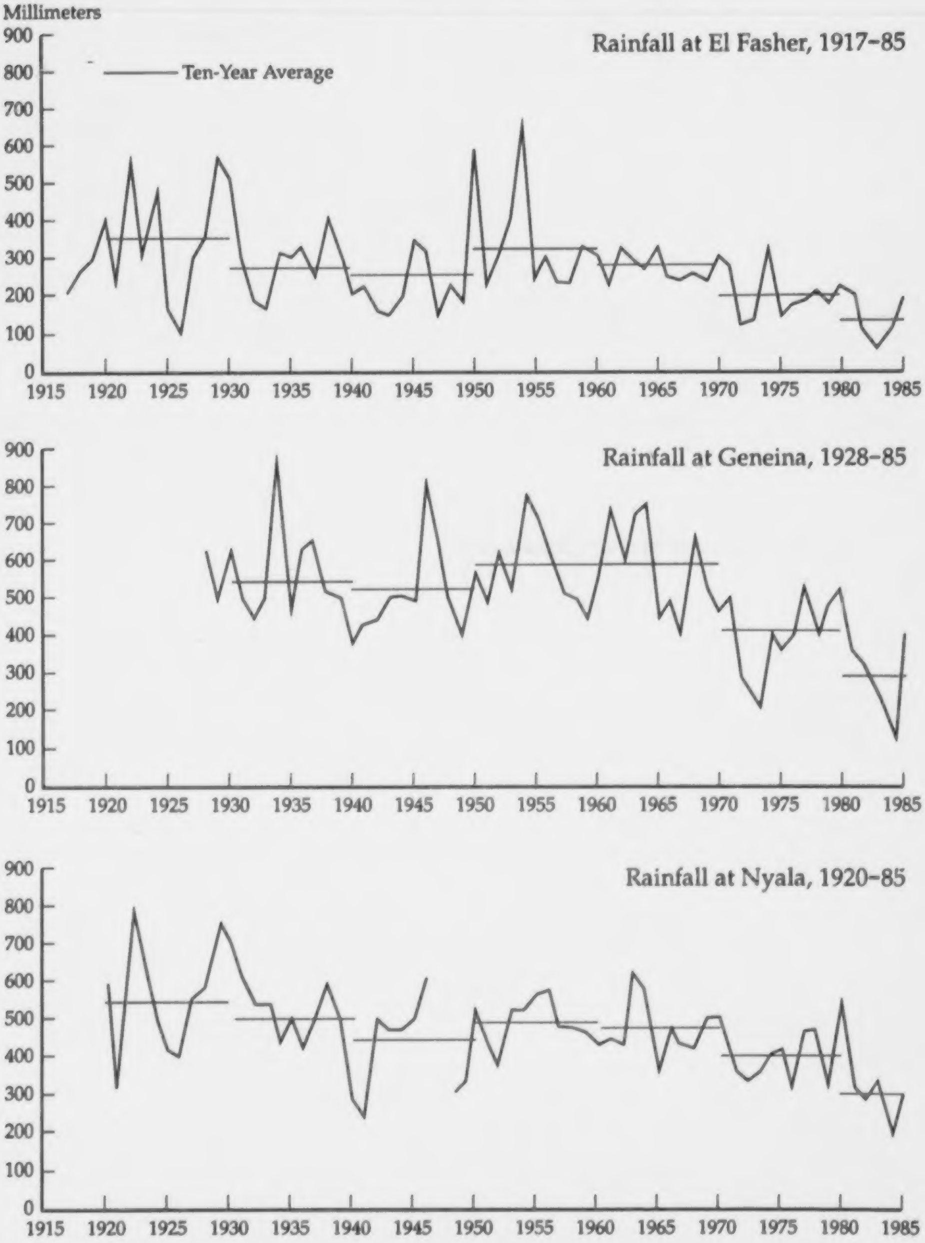
[2] The IFPRI survey covered 240 sedentary households in 10 villages of Bara and El Obeid districts in 1989. Villages were sampled to reflect variations in the 1984-85 drought-related famine experience, their degree of involvement in rehabilitation projects, and access to water sources and main towns. A sample of households was drawn from the project-based stratified frame of participants and eligible nonparticipant households.

Figure 6—Rainfall at selected sites in western Sudan, 1917–85



Source: Jeremy Swift and John Grey, "Report on Darfur Region Food Security Policy and Planning" (Institute of Development Studies, University of Sussex, Sussex, 1989, mimeographed).

Table 3—Index of production, area, and yield of major crops in Northern Kordofan, 1974-85

Source/Crop	Index					Average, 1974-81
	1974-81	1982	1983	1984	1985	
						(1,000 metric tons)
Production						
Millet	100	38	46	14	151	146.6
Sorghum	100	54	20	8	19	100.1
Sesame	100	61	42	10	73	66.9
Groundnuts	100	32	22	6	24	189.8
						(1,000 feddans)
Area						
Millet	100	97	106	135	177	1,136
Sorghum	100	92	91	62	36	486
Sesame	100	79	81	74	81	859
Groundnuts	100	78	69	53	21	723
						(kilograms/feddan)
Yield						
Millet	100	39	43	10	85	130
Sorghum	100	61	23	13	56	198
Sesame	100	76	51	13	89	79
Groundnuts	100	41	32	11	112	207

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Yearbook of Agricultural Statistics* (Khartoum: MANR, 1970, 1984, 1987); and Sudan, Ministry of Agriculture and Natural Resources, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

Table 4—Household crop production in 10 Kordofan villages, 1983-88

Crop/Season	Percentage of Area Harvested	Output per Area Planted	Output per Capita
		(kilograms/hectare)	(kilograms/person)
Millet			
1983	82	101	83
	(0.31)	(0.77)	(1.13)
1984	17	6	4
	(2.32)	(4.20)	(4.12)
1985	78	118	97
	(0.33)	(0.89)	(1.35)
1987	37	26	18
	(1.25)	(2.16)	(2.84)
1988	82	124	80
	(0.32)	(0.81)	(0.99)
Sesame			
1983	80	86	64
	(0.31)	(0.92)	(1.43)
1984	25	8	6
	(1.89)	(3.89)	(3.67)
1985	70	70	46
	(0.42)	(0.93)	(1.29)
1987	86	79	58
	(0.26)	(0.87)	(1.30)
1988	85	75	50
	(0.28)	(0.79)	(1.07)

Source: International Food Policy Research Institute survey, 1989.

Note: Figures in parentheses are coefficients of variation.

Farmers in Northern Darfur also experienced years of consecutive crop failures in the 1980s (Ibrahim 1990). Occurrence of crop failures was noted in some parts of Northern Darfur in 1982 and 1983; for example, Um Kaddada Area Council in the east. However, the crop failure of 1984 was severe and extensive. Production of millet, the main staple food for the inhabitants of Northern Darfur, reached a low of 14 percent in comparison with the 1981 level. The average yield reached 18 percent of the normal level in the same year. Despite improvement in total rainfall in 1985, some areas of Northern Darfur continued to experience crop failure.

Stock of Animals. Poor grazing and health conditions, which worsened in 1984, resulted in large livestock losses. The 1984-85 period witnessed a sharp decline in growth rates of herds due to high mortality rates, distress sales, and low birth rates. Estimates of livestock losses in IFPRI survey villages indicate that herd size, which averaged about 2.0 livestock units per capita by the end of 1983, dropped to 0.26 units by the end of 1985—a drop of 86 percent (Table 5). The largest drop occurred in the case of cattle. By the end of 1985, the share of cattle in herd composition was 2.2 percent. Goats, on the other hand, gained a more prominent position—as much as 52 percent, compared with 35 percent at the end of 1983.

Mortality rates were relatively high for the less drought-resistant animals—cattle and sheep (Table 6). Cattle and sheep require relatively shorter drinking intervals (3-5 days)—much shorter than camels, which are served in intervals of 9-15 days. Sheep are also selective in their grazing behavior, both in type of feed and timing of feeding. Cattle and sheep were highly vulnerable to poor pasture and water conditions and a worsening disease environment. The young and the pregnant or lactating females were the most vulnerable in all species, causing great damage to future restocking capacity. According to the 1986 official survey in northern and eastern Kordofan, the losses were much greater in the northern arid zones, where shortage of pasture and water was intense (KRMFEP 1986).

Table 5—Herd size and distribution among rural households in Kordofan, 1983-88

Item	1983	1984	1985	1987	1988
Livestock per capita (LSU)[a]	1.91	0.62	0.26	0.31	0.36
			(percent)		
Herd composition					
Cattle	37.12	23.26	2.21	1.44	1.11
Sheep	6.75	4.33	4.28	3.68	4.59
Goats	34.57	38.54	51.96	55.88	56.51
Donkeys	13.07	17.64	28.84	24.40	23.19
Camels	8.49	16.23	16.71	14.60	14.60
Livestock-owning households					
Cattle	58.0	25.0	3.6	2.7	2.7
Sheep	18.4	7.6	5.1	5.4	7.5
Goats	83.7	56.9	61.6	74.8	83.7
Donkeys	77.6	42.4	41.3	55.8	60.5
Camels	43.5	29.9	24.6	23.1	25.6

Source: International Food Policy Research Institute survey, 1989.

[a] In livestock units, cattle = 0.83, goats/sheep = 0.20, camels = 1.0, and donkeys = 0.50.

Table 6—Change in growth rate and growth components of livestock in Kordofan, 1983-88

Species	Year	Growth Rate	Growth Component: Birth Rate	Mortality Rate	Net Off-take[a]	Other Losses[b]
			(percent of change)			
Cattle	1984	-73.0	15.1	-47.9	-25.8	-14.5
	1985	-92.0	1.9	-53.0	-23.0	-18.0
	1986	-8.6	20.0	-8.0	-16.6	-4.0
	1987	17.4	21.7	-4.3	0.0	0.0
	1988	22.2	25.9	0.0	-7.4	3.7
Sheep	1984	-80.5	21.3	-45.8	-44.4	-11.6
	1985	-57.3	11.5	-27.1	-26.0	-15.6
	1986	14.6	31.7	-4.9	4.8	-17.1
	1987	6.4	38.3	-17.0	-8.5	-6.4
	1988	16.0	n.a.	n.a.	n.a.	n.a.
Goats	1984	-65.0	25.6	-31.4	-33.2	-26.1
	1985	-14.3	54.1	-34.2	-19.1	-15.1
	1986	24.6	70.8	-11.6	-19.0	-15.6
	1987	14.9	74.9	-21.1	-23.7	-15.2
	1988	17.5	70.2	-23.9	-17.0	-11.9
Camels	1984	-45.6	0.9	-26.3	-17.5	-2.6
	1985	-27.4	1.6	-19.4	-6.5	-3.2
	1986	13.3	13.3	-4.4	4.4	0.0
	1987	9.8	11.8	-3.9	7.8	-5.9
	1988	16.1	12.5	-1.8	3.6	1.8

Source: International Food Policy Research Institute survey, 1989.
Note: n.a. means not available.
[a] Net off-take equals sales minus purchases.
[b] Other losses include slaughtering, gifts, thefts, and unspecified disappearances.

Birth rates were too low in these years to offset the high losses. Production response indicators in Table 7 show that calving intervals and suckling periods are longer and growth is slower in drought years. Poor physical condition due to starvation and disease, and the need to suckle offspring for a longer period contribute to a shorter calving interval. This is evident from much-reduced birth rates in the 1983-85 period. And the animals that were born were slow to reach maturity. The natural process was thus self-regulated to maintain pace with the surrounding environment.

A similar pattern was evident in Darfur. Animal losses were much higher in the north than in the south. For example, 71 percent of the cattle and 40 percent of the goats in the north were lost. The south lost 37 percent of the cattle and 10 percent of the goats. The camel-herding nomads of the north suffered the most. Ibrahim (1990) noted losses of as much as 70-90 percent of camels among the camel herders, particularly the Medub tribe. The sedentary farmers also witnessed a sharp drop in their livestock. Among sedentary farmers interviewed in Northern Darfur, 44 percent reported loss of all their sheep and 14 percent reported total loss of goats (Ibrahim 1990). Less than 10 percent of the sample managed to maintain their herds throughout the drought years.

Table 7—Variation in animal production response between normal and drought years in Southern Darfur

	Age at Maturity		Suckling Period		Calving Interval	
Species/Sex	Normal Years	Drought Years	Normal Years	Drought Years	Normal Years	Drought Years
			(months)			
Cattle						
Male	43.2	62.7	. . .	. . .	. . .	. . .
Female	38.8	59.2	7.8	14.1	12	23
Sheep						
Male	10.7	15.3	. . .	. . .	. . .	. . .
Female	8.6	15.4	4.8	7.9	7	13
Goats						
Male	7.1	12.3	. . .	. . .	. . .	. . .
Female	7.4	11.8	4.3	7.7	7	11

Source: Sudan, Ministry of Agriculture and Natural Resources, *Pilot Survey of Livestock Production and Marketing in Southern Darfur: With Emphasis on 1983-85 Drought Effects (Khartoum: MANR, 1987).*

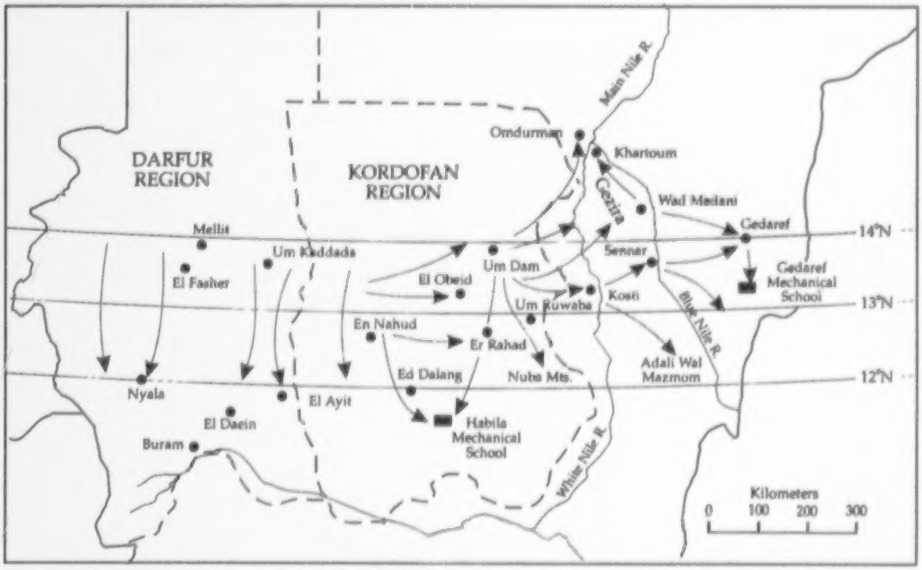
The effects of large losses are evident in the ownership of livestock in the postdrought years. In 1985, livestock assets in 10 IFPRI survey villages in El Obeid and Bara districts of Northern Kordofan reached 14 percent of their 1983 level. By 1988, they had recovered only to 19 percent of the 1983 level. The gradual buildup has shown an increased concentration on low-cost and drought-enduring animals.

Distress Migration. The nomads have adjusted their seasonal movements over the years in response to periodic drought conditions. In normal years, the camel-herding nomads of the north move their herds northward at the onset of the wet season. At the end of the wet season, they move the herds southward toward the southern fringe of the semidesert belt (around 14° north latitude) or to the Sahelian belt (12° north latitude to 14° north latitude) and settle around water points during the dry season. The cattle owners of the south move northward at the onset of the rain as far as 13° north latitude and stay below 10° north latitude during the dry season.

A baseline survey in Sodari district in Northern Kordofan reveals that the northern pastoralists have increasingly shifted their southward movement (*darat* grazing) to October instead of beginning it as late as January (el-Sammani et al. 1984). Ibrahim (1985) also noted from a sample of nomads that since 1979, 43 percent had changed the areas where they spent the dry months. In recent years the northern nomads of Kordofan have intensified their penetration deep into the south below 12° north latitude. By 1983, for example, the Kababish tribe of the north was found deep in the southern reaches of Kordofan (el-Sammani et al. 1984).

Distress migration was also observed among the northern nomads in Darfur in the 1983-85 period (Figure 7). Most of the Medub tribe lost their camels and moved to eastern Darfur to work as agricultural laborers or to a relief camp in Mellit town. The Zaghawa tribe started to migrate from their tribal land at the end of 1983 and settled south of El Fasher with their relatives who had moved earlier, during the droughts of the 1970s. They also migrated to areas in Southern Darfur (Buram and

Figure 7—Migration trends of peasant farmers in the semi-arid and central parts of Sudan


DARFUR REGION
KORDOFAN REGION
Main Nile R.
Omdurman
Khartoum
Gezira
Wad Medani
Gedaref
14°N
Mellit
Um Keddada
El Fasher
Um Dam
El Obeid
Sennar
Gedaref Mechanical School
Kosti
Um Ruwaba
13°N
En Nahud
Er Rahad
Blue Nile R.
Adali Wal Mazmom
Ed Dalang
Nuba Mts.
12°N
Nyala
El Ayit
El Daein
Habila Mechanical School
Buram
White Nile R.
Kilometers
0
100
200
300

Source: Based on data from Mohammed Babiker Ibrahim, "Adjustment to Drought Hazard in the Semi-Arid Areas of the Sudan" (Ph.D. diss., University of Alberta, Edmonton, Alberta, Canada, 1985).

El Daein) and outside the region to Omdurman and the irrigated scheme in Gezira Province. The Zayadia nomads also moved from Mellit to Southern Darfur and the El Daein area.

High rates of migration were also recorded in the Kordofan sedentary sample (Table 8). In one village, as many as 95 percent of the IFPRI sample families had at least one migrant member, the rate of migration per family reached a high of 89 percent, and whole-family migration reached 74 percent. Large-scale movements involving whole families were also evident in other parts of the region. A study among sedentary farmers in eastern Kordofan revealed that, from a low of 14.7 percent in 1980/81, the percentage of households that migrated with whole families reached 45.9 percent in the peak drought year of 1984/85 (Mohammed 1988).

There are some notable developments in the postfamine period. First, the whole-family migration rate dropped considerably in the years following the 1984-85 period. Second, high proportions of rural families continue to migrate in comparison with their migration in prefamine years. However, the migration rate per family has come back down to the level of the prefamine period. Third, migration continues to be seasonal and of short duration, except for international migrants, who are often young men with a better financial base.

Employment and Income. The decline in production that occurred in 1984 translated into a large drop in farm employment. Despite an expansion of area planted, especially millet fields, farm employment dropped after planting by an average of 70-75 percent from a normal (four-year moving average) level (Table 9).

Table 8—Short-term migration rates for selected survey villages in Kordofan, 1983-88

Village/Year	Percentage of Families with at Least One Migrant	Rate of Migration: Migrants per Family	Rate of Migration: Whole Families
		(percent)	
Abukhrais			
1983	25	12	8
1984	42	15	8
1985	67	44	29
1987	42	14	4
1988	50	19	17
El Felia			
1983	33	23	14
1984	48	36	29
1985	67	52	48
1987	43	21	10
1988	52	23	10
Wed Eldeik			
1983	11	7	0
1984	43	38	37
1985	95	89	74
1987	48	19	5
1988	33	18	5

Source: International Food Policy Research Institute survey, 1989.

Table 9—Farm size, labor use, and value of crop output in Kordofan, 1983-88

Crop/Season	Farm Size	Labor Use	Employment per Farm	Current Value of Output per Capita	Constant Value of Output per Capita in 1983 Prices
	(hectares)	(man-days/ hectare)	(man-days)	(SD£)	
Millet					
1983	4.4	20.0	88	51	51
1984	4.0	6.3	25	6	4
1985	4.4	18.2	80	43	49
1987	3.1	14.0	43	31	41
1988	4.2	18.5	78	121	59
Sesame					
1983	3.7	24.7	91	71	71
1984	2.6	8.6	22	8	6
1985	2.9	18.4	54	71	81
1987	4.3	16.4	71	108	142
1988	3.9	27.5	107	140	68

Sources: International Food Policy Research Institute survey, 1989; and Abdel Latif Ijami and Ronald D. Krenz, *Crop Production, Costs and Returns to Family Land in the Traditional Rainfed Areas of Sudan: A Five-Year Summary, 1984/85-1988/89* (Khartoum: Ministry of Agriculture and Natural Resources, 1990).

Typically, 17 percent of millet labor and 22 percent of sesame labor in Northern Kordofan comes from nonfamily labor in a normal year. Landless as well as capital-constrained landowning families often work in the villages for wages. Abandonment of farm work in 1984, therefore, hit these groups hard. A study that traced the rate of off-farm agricultural employment of sample participants in eastern Kordofan also supports a substantial decline in employment opportunity (Mohammed 1988). The percentage of families who worked as local agricultural laborers dropped from 18 percent in 1983/84 to 3.1 percent in 1984/85.

The large drop in employment occurred at the same time there was a glut of people seeking work. The decline in agricultural income as well as asset position precipitated a large drop in farmers' reservation wages, which translated into high entry into the labor market. Increased participation of women in the labor force was particularly notable. The women from IFPRI survey villages, for example, engaged in housekeeping employment in urban areas—a type of work not customary in Sudanese culture. Wage rates consequently fell in rural labor markets. In the survey area, for example, a day of labor could buy only 2 kilograms of millet in 1984, compared with 6 kilograms in 1983.

There was a nearly complete collapse in crop income, which normally accounts for one-third of household income. Moreover, since nearly half of household income is from rainfall-dependent agricultural income sources (crop production, local farm wage employment, and livestock), the extent of income failure was much greater. When farmers faced a severe decline in their agricultural income, they resorted to sale of assets, collected products, and nonagricultural income. A sizable fraction of the sample derived their income primarily from liquidation of assets and nonagricultural income sources (handicrafts and wage labor). Loans and transfer receipts also enhanced income. Those in a better wealth position engaged in large-scale selling of their assets (livestock and other household valuables). The asset-poor had to depend greatly on handicrafts and transfers to augment their low income from sale of assets.

Demographic Effect. By and large, the 1984-85 famine contributed to slow growth in the population of the survey villages. The natural growth rate dropped from an annual rate of 2.7 percent in 1983/84 to 2.3 percent in 1984/85. However, a high rate of out-migration, especially in the short run, caused a large drop in village population. A most notable case was in Bara district villages, such as Um Sot, where the resident population dropped appreciably because of large-scale emigration.

No significant excess mortality rate was evident in the survey villages in 1985—the year when demographic change could be presumed to show a sizable shift. The crude mortality rate increased, but not as progressively as expected in a period of low food intake and high incidence of disease. Thus, the expected increase in the spread between high mortality and low fertility was not evident in the survey villages. This fails to concur with de Waal's (1987) findings for Darfur, the region further to the west of Kordofan, of a decline in the natural growth of village population due to an excess mortality rate coupled with a decline in birthrate.

These results are, of course, specific to study areas. Various pieces of evidence point out that significant demographic change has occurred in the much drier areas of Northern Kordofan. Estimates of famine-related deaths are tentative. There is strong evidence of a permanent out-migration to the central zone of Kordofan, and to the Central and Eastern regions of Sudan (Khalil 1987; Ibrahim 1985, 1990). High net permanent out-migration must have been a strong factor in depopulation of these hard-hit areas.

Household-Level Coping Strategies

There is emerging evidence that provides insights into household coping behavior in periods of food crisis (see, for example, Jodha 1978; Corbett 1988; von Braun and Teklu 1989; Campbell 1990). Corbett, for instance, synthesizes existing knowledge of strategies and responses common in African settings. Von Braun and Teklu reexamined these responses in the context of three African countries (Rwanda, The Gambia, and Sudan) in order to understand interhousehold variations in success of coping with crises and with regular and predictable situations.

Studies on Sudan (de Waal and el-Amin 1986; de Waal 1987; Osborne et al. 1986) point out some common coping features: increased rate of migration, including whole families; shift in income sources toward sale of livestock, personal possessions, and transfers; reduction in frequency and size of meals; greater consumption of tree fruits; and greater dependence on markets for acquisition of food and sale of labor. Intrahousehold food-sharing and transfers are more common among relatives.

The findings of this study are not conclusive as to the specific ordering of these responses (Table 10), but there are notable patterns. Household responses involve substitutions between and within consumption-income and asset paths. There are discrete shifts in these paths (strategies), but responses are simultaneous across the paths. Households vary in their emphasis on choices among these strategies and responses. In general, they prefer to avoid action that would endanger their future survival. However, coping success is unequal across households because of an unequal endowment base, unequal access to a community risk-sharing network, and unequal public support.

Production Response. Farmers in general prefer to maintain diversified crop portfolios. Typically, a few crops dominate, and these are often a mix of staple and cash crops (Table 11). This was the case in the Kordofan sample despite higher relative factor returns of sesame to millet (on the order of 1.4 to 1) in the 1987 and 1988 seasons. Other considerations also enter into the choice of crop mix. Where market transaction costs are prohibitive, as in the case of western Sudan, farmers prefer to maintain food crops in their crop portfolios. Diversity in crop mix also allows farmers to follow a flexible production schedule in terms of their responses to varying rainfall patterns. Typically, farmers in the west shift from millet to other crops (for example, sesame and watermelon) when early rains appear to be inadequate or when rains are concentrated in the latter part of the wet season (late July and August).

In addition to the crop-diversification response, farmers adopt a variety of loss-avoidance or loss-minimization measures. They shift their planting date to before the onset of the first rains (*remail*) to get maximum moisture from a short and intense rainfall. Because of high local variability of rains, it is common to plant each crop in several different locations of different fields. Crops are also planted in larger areas, when land availability permits, to ensure that some area is harvested

Table 10—Time path of drought-coping responses in western Sudan

Source of Adjustment	Stages of Response		
	Early	Intermediate	Final
Production	Change in cropping and planting practices	. . .	. . .
	Increased nonfarm home production		
Labor	Migration in search of employment	Migration in search of employment (intensified in face of falling expected wage rate)	Distress migration
		Separation of family	Separation of family (possibly permanent)
Assets/capita	Sale of small stock (liquid, easily reversible)	Sale of productive assets (livestock, tools, land) in depressed market	. . .
	Sale of large stock (nonessential)		
Loans/transfers	Use of interhousehold transfers and loans	Credit from merchants and moneylenders	Donation (relief assistance)
Consumption	Switch in expenditure/dietary composition	Reduction of consumption (greater dependence on market)	Reduction of consumption (survival may be threatened)
	Reduction of current consumption level (cut in frequency or size of meals or both)		
	Adjustment in intrahousehold allocation		

at the end. Adoption of quick-maturing seed varieties is also on the rise because of the recurrence of droughts (Ibrahim 1985).

Migration Response. Movements of the sedentary agricultural population are characterized in normal years by dry-season migration of working persons. Normally, the sedentary cultivators leave their farms at the end of the harvest period (December or January) and return in April or May to prepare their own farms. In short, migration is voluntary, seasonal, and involves adult members of a household. The migration rate per household ranges from 13 to 20 percent in normal years.

However, large-scale movements began soon after the farmers realized that the 1984/85 crop year was a complete failure. According to a survey of displaced households from western Sudan who settled around Omdurman, 74.9 percent came in September and October (Table 12)—much earlier than the normal January to May dry-season migration.

Table 11—Crop diversification of farm households under drought in Kordofan, 1983-88

Crop	Season	Share of Farms Growing the Crop[a]	Share of Value of Production
		(percent)	
Millet	1983	84	32
	1984	23	31
	1985	83	23
	1987	41	13
	1988	91	41
Sorghum	1983	4	10
	1984	8	18
	1985	25	8
	1987	30	14
	1988	48	9
Sesame	1983	84	49
	1984	28	33
	1985	89	48
	1987	90	43
	1988	93	47
Watermelon	1983	. . .	4
	1984	. . .	16
	1985	. . .	6
	1987	. . .	16
	1988	. . .	4

Source: International Food Policy Research Institute survey, 1989.

[a] Only those who participated in the production process up to and including harvesting are considered as participants.

Table 12—Arrival time of displaced population around Omdurman, 1984

Month	Percentage of Population
March	0.9
July	3.0
August	5.6
September	34.0
October	40.9
November	10.4
December	5.2

Source: Based on data from S. S. Khalil, *The Socioeconomic and Political Implications of the Environmental Refugees in the Vicinity of Omdurman*, Monograph 6 (Khartoum: University of Khartoum, Institute of Environmental Studies, 1987).

Migration in Northern Kordofan took different directions, but because of diminished farm-employment opportunities, the emphasis was toward nearby towns and major cities. The study in eastern Kordofan shows that the percentage of migrants who moved to urban areas (mainly Omdurman and Um Ruwaba) peaked at 63.8 percent in 1984/85 from the preceding four-year average of 5.4 percent (Table 13). A survey of displaced population from eastern Bara, eastern Sodari, and Um Ruwaba districts showed that 40, 53, and 45 percent, respectively, of the district's total population moved to nearby towns and Khartoum (Table 14).

Notable changes have also been observed in the migration pattern of the sedentary population during recent droughts. In Darfur, large-scale migration was directed to the better rainfall areas of the south, especially to the Jebel Marra Highlands and surrounding alluvial plains. Others moved to the larger cities of Northern and Southern Darfur—El Fasher, Nyala, and Zalengi. Those without prior experience of migrating for seasonal work and resource base opted to move either to areas where they had relatives or access to casual work or to famine-relief camps.

These variations in migration responses indicate the important influence of proximity to urban areas, ecological variation (for example, presence of vegetation as a source of direct food and cash income), and distance to water points. Distress migration was high in areas where the agricultural resource base was limited, alternative income sources were absent, and critical survival food was not easily affordable and accessible. Also, where the social support network was discriminatory (as was the case for recent residents in some villages), the disadvantaged were forced to migrate.

In addition, there were household-specific factors that contributed to out-migration. An attempt to capture these variables was made in the context of a dichotomous logit decision model. The estimated (log) odd-ratio parameters and associated mean-level evaluated probabilities provide additional insights on the decision to migrate or not (Table 15).

Table 13—Percentage and destination of migrants from sedentary households in East Kordofan, 1980/81-1986/87

	Household Migrants		Destination of Migrants		
Season	One Person	Whole Family	Urban	Gezira	Rainfed Area
			(percent of households)		
1980/81	10.7	14.7	4.2	89.3	6.5
1981/82	10.6	15.8	4.7	77.5	17.8
1982/83	13.0	17.3	5.2	48.9	45.9
1983/84	11.2	15.3	7.6	40.7	51.7
1984/85	7.7	45.9	63.8	26.6	9.6
1985/86	21.0	10.0	41.1	22.7	36.1
1986/87	21.4	7.0	44.4	16.9	38.7

Source: Based on data from Mohammed Abdel Gadir Mohammed, "The Impact of Emergency Food Aid on Traditional Agricultural Production Systems—The Case of East Kordofan District" (M.S. thesis, University of Khartoum, 1988).

Table 14—Percentage of population migrated from East Bara, East Sodari, and Um Ruwaba, by destination, 1984-85

District/Village of Origin	Migrants	Destination					
		Adjacent Villages	Nearby Towns	Southern Kordofan	Khartoum	Gezira	Other
	(percent of population)	(percent of village migrants)					
East Bara							
Malagat (Risa)	30	12	24	20	13	11	20
Abu Shouk	56	12	16	8	26	19	19
El Saafa	27	9	12	13	29	21	16
East Sodari							
El Shatoot	42	2	11	6	48	24	9
Um Surra	82	6	23	13	31	20	7
Sowdary	25	3	14	17	36	21	9
Tenna	35	6	13	11	31	22	17
Hamrat El Wiz	18	6	21	11	36	14	12
El Hagab	50	6	21	8	36	20	8
Huffra	7	6	18	6	26	22	22
Um Khirwi	11	7	20	9	39	13	12
Um Ruwaba							
Brima Elnar	42	12	34	18	14	10	12
Tip El Haloof	20	19	29	11	21	11	9
Um Ruwaba	15	13	33	20	17	9	8
Koz El Bagara	43	14	33	21	13	9	10
El Malaga	48	12	22	17	17	16	16
Shurkaila	6	4	29	20	16	14	17
Gabsha	12	12	29	20	15	12	12
Braissa El Ragig	50	9	11	10	28	32	10
El Simeh	9	3	16	14	29	20	18

Source: KRMFEP (Kordofan Regional Ministry of Finance and Economic Planning), *The Current Situation of Livestock in North Kordofan—Part I* (El Obeid, Kordofan: KRMFEP 1986).

- The odds are higher for migration of families headed by males than for those headed by females.
- Ownership of livestock reduces the probability of out-migration. It is the poor who are prone to migrate.
- Families with large numbers of dependents are most likely to migrate, indicating distress migration.
- The odds of migrating are higher where there is no access to a water source within a village.
- In addition to the aforementioned factors, others contributed to high out-migration in two IFPRI survey villages that experienced high rates of migration during the peak of the famine. These are captured in the dummy variables and may reflect differential access to vegetation (pasture, free crops) and access to outside sources of income such as remittances.

Livestock Response. The desire of farmers to protect a minimum viable number of their livestock to ensure continuity of future productive capacity was evident in their actions in 1984-85. They pursued a course that involved extensive change in feeding sources and practices, a shift in the composition of livestock varieties, and the movement of animals to areas perceived to have better pasture and water.

Table 15—Maximum likelihood estimates for short-term migration of survey households, logit model

Explanatory Variable	Parameter Estimate (t-Statistic)	Change in Probability[a]
Age of head of household (in years)	-0.02 (-0.18)	. . .
Sex of head of household (1 if male, 0 otherwise)	1.20 (2.54)*	. . .
Migration experience (1 if migrated in previous season, 0 otherwise)	18.59 (0.01)	. . .
Per capita livestock, 1983 (LSU)[b]	-0.74 (-2.98)*	-0.0159
Adult-to-family ratio	-2.24 (-4.00)*	-0.0480
Water source (1 if village has permanent water source, 0 otherwise)	-1.79 (-4.86)*	. . .
Village dummy (1 if village experienced large-scale migration, 0 otherwise)	4.55 (11.60)*	0.0975
Constant term	-2.23 (-2.96)*	
Log LF[c]	-145.0	

Source: International Food Policy Research Institute survey, 1989.

[a] Evaluated at sample mean point.

[b] LSU = livestock unit.

[c] An alternative measure of goodness of fit involves a correct classification of households as either migrating or not. The model correctly classified 95.4 percent of the households.

*Significant at the 99 percent confidence level.

Variations between these principal responses were conditioned on the rapidity and intensity of the drought, market conditions, and the resource capacity of the farm population.

A great majority of the farmers in the survey area attempted to make up the shortage of pasture by shifting to purchased feeds (at times this was done by selling part of the livestock) or collected plants. Farmers also split their stocks, sending some to distant areas for better grazing—a practice rarely followed by sedentary farmers, particularly small-herd owners. However, access to permanent water yards and better pasture routes was often limited to those who had a financial advantage or social ties. As the drought continued, farmers' capacity to feed their animals was increasingly constrained by shortages of pasture and water and rapidly declining income capacity. Farmers had to dispose of their more valuable animals to fetch the best price possible in the depressed market or to avoid imminent loss due to livestock death.

The farmers engaged in large-scale dispossession of their livestock. The off-take rates for these animals were much higher than the normal rates (Table 16).

Table 16—Livestock losses among sedentary farmers in East Kordofan, 1984-85

Species	Death	Sale
	(percent)	
Cattle	70.0	30.0
Sheep	65.0	35.0
Goats	78.0	22.0
Camels	82.0	18.0
Donkeys	96.0	4.0

Source: Based on data from Mohammed Abdel Gadir Mohammed, "The Impact of Emergency Food Aid on Traditional Agricultural Production Systems—The Case of East Kordofan District" (M.S. thesis, University of Khartoum, 1988).

Note: The estimated-off-takes from the livestock population in El Obeid market in 1982 were cattle, 19 percent; sheep, 10 percent; goats, 3 percent; and camels, 8 percent (Louis Berger International 1983).

Such increased off-take was made possible by the sale of animals that often had not been destined for market. The normal preference is to sell adult males, cows that cease to produce or fail to give regular birth, and calves that are considered in excess of what is necessary for replacement of stocks. This selectivity process diminished in the 1984-85 period as farmers were forced to dispose of their animals. These animals, weakened by starvation and disease, often fetched low prices in the already depressed market.

Income Response. Farmers in the survey villages derive their income from diverse sources, principally crop and livestock production, collected products, transfers, and wage income. Within these income sources is a multitude of individual sources, but a few of them always dominate.

The relative position of these income sources in household income in 1988 is shown in Table 17. Eighty-five percent of the average income is earned income. Among agricultural income sources, crop production accounts on average for 30 percent. When it is combined with farm wage income, the average moves close to 37 percent. If livestock income is added, the average reaches 50 percent. Thus, about half of the income of the survey population comes from rainfall-dependent agricultural sources. The other important source of earned income is the sale of collected products (firewood, poles, charcoal, and grass). Transfers play a crucial stabilization role in a period of falling agricultural income—a recurrent event in recent years.

A comparison of mean income variations shows significant disparity; the high-income tercile has an income level that is four times higher than that of the low-income tercile (Table 17). Female-headed households make less income on average than male-headed households. Although poverty is widespread, it is not uniform among the farm population.

No considerable differences are seen between high- and low-income groups in their income composition, especially within earned-income categories. However, there are important variations in the income shares of transfers and collected products. Across genders, the important sources of differences are in crop and transfer incomes. Crop production is a relatively significant income source for male-headed households. Female-headed households tend to compensate for their

Table 17—Shares of income sources, by income group and sex of family head, 1988

Income Source	Whole Sample	Income Group		Family Head	
		Low Tercile	High Tercile	Male	Female
			(percent)		
Agricultural income	52.2	50.1	50.7	54.9	44.1
Crops and crop products	30.0 (100.0)	25.4 (100.0)	29.5 (100.0)	31.8 (100.0)	24.0 (100.0)
Farm wage	6.6 (70.0)	8.9 (77.0)	5.4 (60.0)	6.9 (72.0)	5.9 (68.0)
Livestock and livestock products	13.5 (95.0)	14.2 (90.0)	13.2 (96.0)	13.6 (96.0)	13.5 (91.0)
Nonagricultural income	29.4	35.3	28.2	30.4	26.6
Collected products	14.5 (97.0)	21.4 (96.0)	11.4 (98.0)	13.9 (99.0)	16.4 (91.0)
Handicrafts	2.6 (66.0)	4.6 (75.0)	2.1 (54.0)	2.4 (62.0)	3.5 (77.0)
Trading	4.9 (17.0)	1.1 (6.0)	7.6 (33.0)	5.8 (17.0)	2.3 (17.0)
Nonfarm wage	3.5 (18.0)	3.7 (17.0)	2.6 (17.0)	4.6 (25.0)	0.3 (2.0)
Transfers[a]	18.4 (68.0)	14.6 (63.0)	21.1 (85.0)	14.7 (59.0)	29.3 (91.0)
Remittances	8.5 (50.0)	4.3 (48.0)	11.8 (65.0)	7.0 (43.0)	13.1 (66.0)
Annual income per capita (SD£)	1,100	500	1,866	1,169	942

Source: International Food Policy Research Institute survey, 1989.

Note: Figures in parentheses refer to the percentage of participating families in the sample.

[a] Figures for transfers include remittances.

low agricultural income largely through transfers. Handicrafts are a minor but essential compensatory income source.

A considerable substitution between income sources was also evident in 1984-85 (Table 18). When farmers faced failure in their crop income, they resorted to sale of assets, collected products (grass, firewood, and so forth), and nonagricultural income. A sizable fraction of the sample derived their income primarily from liquidation of assets and nonagricultural sources (handicrafts and wage labor). Receipts in the form of loans and transfers also enhanced their income. Those in a better wealth position sold a large part of their assets (livestock and other household valuables). The asset-poor had to depend greatly on handicrafts and transfers to augment their low income from sale of assets.

The observed income response of the sample households is that when a large share of income is derived from crop-based activities (including wage income), all households share a greater risk of income failure. The current protective income sources (income from sale of collected products and transfers) are easily reversible

Table 18—Distribution of households by source of income, Kordofan survey villages, 1984-85

Income Source	Whole Sample	Wealth Group[a] Low	Wealth Group[a] High
	(percent of households)		
Sale of assets			
Livestock	62	55	66
Durables	32	17	45
Handicrafts	20	36	11
Wage labor	28	38	23
Loans	17	24	15
Transfers	26	36	21

Source: International Food Policy Research Institute survey, 1989.

[a] Bottom and top terciles of distribution of livestock ownership in 1984-85

and nonsustainable, particularly when viewed in terms of their implications for the environment. Furthermore, it is evident that the burden of coping is unequal and falls heavily on those who depend largely on crop-based income and have few protective income sources or assets. Households from the drier areas, especially asset-poor households headed by women and those headed by the old without working members, are at high risk.

To capture these factors that contribute to interhousehold income variations, income determination equations were estimated relating per capita household income to asset ownership, family labor, age of household head, sex of household head, education of household head (binary variable for having formal education or not), income source, and relative village effects in 1988/89. Estimates of variants of the income model are in Table 19. Variant 1 explains per capita earned income. Variants 2 and 3 are related to total income. Although transfer income may be considered as exogenous to household decisionmaking, its large share may pose a simultaneous bias problem. An alternate specification that was estimated without share income is thus included in the table.

The results confirm key hypothesized relations: the wealth and size of the labor force have major influences on household income; there is a gender bias in income variations—female-headed households earn much lower income than male-headed households; the education of the household head has an income effect; transfer income is important, especially as a substitute for earned income; and villages in the drier areas of the sample have much lower income per capita.

Consumption Response. The major diet component in the survey areas is millet-based porridge (*asida*) served with sauce or milk. At times, bread from sorghum (*kisra*) is served with a mild, spiced stew. An average family serves at least two meals per day, usually in the late morning and late afternoon. A light meal may be served in the evening. Hot tea is frequently served during the day, particularly after meals.

The key food ingredients that contribute to this diet are millet (cereal), cowpeas (legume), okra (vegetable), meat and milk (livestock products), sugar, tea,

Table 19—Determinants of household income, Kordofan survey villages, 1988/89

	(Variant 1) Earned Income	(Variant 2) Total Income	(Variant 3) Total Income
Explanatory Variable	Parameter Estimate	Parameter Estimate	Parameter Estimate
Adult-to-family ratio	478.52	560.77	665.43
	(2.96)	(2.79)	(3.22)*
Age of head of household (years)	29.29	18.64	3.54
	(1.62)	(0.83)	(0.15)
Age of head of household squared (years)	-0.26	-0.15	-0.01
	(-1.54)	(-0.71)	(-0.04)
Education of head of household (1 if formal education, 0 otherwise)	278.99	358.67	293.28
	(2.15)*	(2.22)*	(1.75)
Sex of head of household (1 if female, 0 otherwise)	-365.87	-535.03	-321.38
	(-3.36)*	(-3.95)*	(-2.55)*
Livestock per capita (LSU)[a]	624.82	800.31	922.05
	(5.40)*	(5.55)*	(6.33)*
Village dummy (1 if village from drier area, 0 otherwise)	-440.49	-574.00	-493.08
	(-3.79)*	(-3.97)*	(-3.32)*
Share of transfer income	-674.97	975.08	. . .
	(-3.01)*	(2.22)*	
Constant	-73.36	28.31	428.68
	(-0.16)	(0.05)	(0.79)
F	11.93	12.30	11.36
$\bar{R}^2$	0.38	0.39	0.34
N	141	141	141

Note: Figures in parentheses are t-statistics.

[a] LSU = livestock unit.

*Significant at the 99 percent confidence level.

and oil (Table 20). The participation is weakly income variant, except for meat and milk, which appear to rise with income level.

The consumption pattern observed in 1989 differs markedly from that practiced during 1985. Families had to cut the frequency as well as the size of meals to ration their food consumption in 1985 (Table 21).[3] About 70 percent of the sample households reported that they had to cut their meal size. One out of three survived

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[3] A survey conducted in September 1984 in three districts of Northern Kordofan (Hamid et al., n.d.) shows that 40 percent of the sample had one or fewer meals during the survey period, compared with 2 percent a year earlier. Nineteen percent of the children had one milk serving a day before the survey, compared with 44 percent a year ago.

Table 20—Monthly expenditure per capita for frequently consumed food items, Kordofan survey villages, 1989

Food Item	Whole Sample	Expenditure Tercile		
		Low	Medium	High
		(SD£)		
Sorghum	3.60 (25)	3.64 (27)	3.82 (31)	3.31 (17)
Millet	16.42 (86)	14.06 (81)	16.66 (88)	18.55 (88)
Cowpeas	3.59 (83)	2.76 (79)	3.57 (86)	4.43 (85)
Okra	8.35 (99)	5.27 (98)	8.85 (100)	10.91 (100)
Meat (beef)	10.99 (59)	5.00 (46)	9.14 (55)	18.88 (77)
Meat (goat)	6.69 (43)	3.58 (35)	6.55 (49)	9.93 (46)
Milk (goat)	8.51 (73)	5.54 (65)	8.34 (71)	11.67 (83)
Sesame oil	8.05 (92)	5.72 (83)	8.84 (96)	9.57 (96)
Sugar	21.42 (99)	14.25 (98)	24.88 (100)	25.07 (100)
Tea	4.29 (98)	3.33 (98)	3.54 (100)	6.01 (96)

Source: International Food Policy Research Institute survey, 1989.
Note: Figures in parentheses are percentages of consuming households in the sample.

Table 21—Consumption responses of sample households, Kordofan survey villages, 1985

Response	Whole Sample	Wealth Group[a]	
		Low	High
		(percent of households)	
Meals per day			
One	34	43	26
Two	38	36	41
Three	28	21	31
Reduced quantities	70	81	64
Collected food	29	21	38
Consumed foods normally not eaten	17	14	19

Source: International Food Policy Research Institute survey, 1989.

[a] Bottom and top terciles of distribution of livestock ownership in 1984-85.

on a single meal. Approximately a quarter of the sample subsisted on a reduced single meal. A greater percentage of these households were from the low-asset group.

The composition of diets shifted largely to sorghum, wheat flour, meats, and wild cereals and tree fruits (wild rice, *kursan*, *nebag*, and *aradabe*). Twenty-seven percent of the sample resorted to consumption of wild rice and tree fruits. Fifty-nine percent of these indicated that they would not have consumed these food items in a normal year. Variation in consumption of these items was largely location-specific. Consumption was much lower in the drier areas, where such plants are less able to grow.[4]

Millet, the main staple in the area, which is usually drawn from own stocks for consumption, was not available in rural markets. Hence the rural population had to depend greatly on the market to obtain its foods. Sorghum and wheat flour were obtained largely from the market. Meats were obtained from own stock as well as the market. Wild rice and tree fruits were partly collected and partly purchased (wild rice—a misleading term, suggests availability at no cost).

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[4] An OXFAM-UNICEF-Kordofan Government study (1985b) shows considerable district variation in the percentage of households that consumed these foods: 79 percent in En Nahud, 63 percent in El Obeid, and 33 percent in Sodari. The availability of such foods diminished northward—particularly in the drier areas, where drought was intense.

4

DROUGHT-PRODUCTION RELATIONSHIPS

The central thrust of this chapter is to establish a quantitative measure between drought and production in the drought-famine chain (Figure 3). As a background, the structure and development of Sudan's agriculture are discussed with emphasis on the performance of cereal production. Trends in rainfall patterns are described, and a model relating rainfall to production is then estimated at country and regional levels, disaggregated by major crops.

Development of Agricultural Production

Agriculture accounted for 48 percent of the gross domestic product (GDP) in 1965. Its relative contribution declined to 39 percent in the 1974-78 period. In the 1980s, its share oscillated between 31 and 38 percent, with the lowest share occurring in 1984 and 1987—the years notable for the lowest rainfall levels (Table 22).

Value added from crop production constitutes the principal source of GDP in agriculture. The crop subsector contributed nearly 60 percent of the sector's value added in the 1981-87 period. Within the subsector, the irrigated crops maintained a relatively stable and large share (60 percent) in the 1980s. Their relative contribution was high in 1984 and 1987 because of a large drop in production of rainfed crops.

The principal crops are cotton, sorghum, millet, wheat, sesame, and groundnuts. Cotton and wheat are irrigated crops grown mainly in the Gezira scheme in Central Region. Cotton is the prime foreign exchange earner, while wheat is an import substitute for the growing urban-based demand. Sorghum is the main staple

Table 22—Relative shares of agricultural components of gross domestic product, Sudan, 1981-87

GDP Component	1981	1982	1983	1984	1985	1986	1987	Average, 1981-87
Agricultural GDP	0.38	0.35	0.35	0.31	0.36	0.35	0.31	0.35
Crops	0.59	0.55	0.55	0.57	0.62	0.58	0.52	0.57
Irrigated	0.41	0.60	0.63	0.75	0.56	0.55	0.67	0.60
Rainfed	0.59	0.40	0.37	0.25	0.44	0.44	0.32	0.40
Mechanized	0.25	0.14	0.14	0.07	0.21	0.24	0.12	0.17
Traditional	0.34	0.26	0.23	0.18	0.23	0.20	0.20	0.23
Livestock	0.33	0.36	0.36	0.32	0.29	0.33	0.38	0.34
Forestry and fishery	0.08	0.09	0.09	0.11	0.09	0.09	0.10	0.09

Source: Based on data files of the Ministry of Finance and Economic Planning, Khartoum.

crop throughout Sudan except in the provinces of Northern Darfur and Northern Kordofan. Even though it is emerging as an important crop in the irrigated schemes, it is mainly grown in rainfed areas under mechanized technology (Table 23). Production is largely concentrated in the central plain that covers Eastern and Central regions, Southern Darfur, and Southern Kordofan (Table 24). Millet and sesame are rainfed crops. Millet, an important staple in the west, is nonmechanized and grows mainly in Darfur and Kordofan (Table 23). Sesame is partly mechanized

Table 23—Shares of crop production in Sudan, by technology type, 1961-86

Crop	Period	Irrigated	Rainfed	
			Mechanized	Traditional
			(percent)	
Cereals				
Sorghum	1961-66	20.9	17.0	62.1
	1974-81	10.7	55.1	34.3
	1982-86	18.3	63.0	18.7
Millet	1961-86	1.2	. . .	98.8
Wheat	1961-86	100.0	. . .	. . .
Oilseeds				
Sesame	1961-66	. . .	8.7	91.3
	1974-81	. . .	29.7	70.3
	1982-86	. . .	49.1	51.0
Groundnuts	1961-66	23.4	. . .	76.6
	1974-81	39.2	. . .	60.8
	1982-86	46.4	. . .	53.6
Cotton	1961-66	91.6	8.4	. . .
	1974-81	95.8	4.2	. . .
	1982-86	96.0	4.0	. . .

Source: Sudan, Ministry of Agriculture and Natural Resources, *Yearbook of Agricultural Statistics* (Khartoum: MANR, 1970, 1984, and 1987).

Table 24—Average production shares of food crops, by main producing provinces, 1974-86

Crop	Province	Region	Production Share
			(percent)
Sorghum	Kassala	Eastern	32.1
	Gezira	Central	10.2
	Blue Nile	Central	22.9
	Southern Kordofan	Kordofan	8.8
Millet	Northern Kordofan	Kordofan	32.2
	Northern Darfur	Darfur	17.4
	Southern Darfur	Darfur	39.6
Wheat	Gezira	Central	73.0

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

and production is spread among Darfur, Kordofan, Central, and Eastern regions. Groundnuts are grown in both irrigated and nonmechanized rainfed areas, but there is a growing shift to irrigated areas, partly in response to low profitability in the western regions, where rainfall is low and highly variable.

Livestock remains an important subsector, with a contribution of one-third of agricultural GDP. Lack of consensus on growth estimates makes it difficult to determine the actual livestock population in the country. The official estimates for 1985 reported 22.1 million head of cattle, 19.3 million sheep, 14.6 million goats, and 2.8 million camels. Most of these stocks are concentrated in Central, Darfur, and Kordofan regions. They are particularly important sources of employment and livelihood for the nomadic population. Lower growth rates in the early 1980s reflected the effects of 1980 droughts, which were characterized by high mortality accompanied by lower birth rates, especially in the western regions (Table 25).

The crop and livestock components are the main influences on the agricultural sector's relative performance. The agricultural GDP, for example, experienced a record per capita fall of 26.4 percent in 1984 relative to the 1983 crop year—assuming a 2.9 percent annual growth in population. There was a recovery in the 1985 season, but this was reversed in 1987. The performance of these components was largely precipitated by continuous failures of rainfed crops and, as in the case of the 1984 season, by large losses of livestock (Table 26).

Cereal Production Performance

Sorghum

Production of sorghum increased from an average of 1.3 million metric tons[5] in the 1961-73 period to 2.2 million tons in the 1974-86 period (Table 27). Area under sorghum increased from 3.9 million feddans to 8.1 million feddans over the same

Table 25—Estimated livestock population in Sudan, 1981-85, and growth rates, 1976-85

	Number			Growth Rates	
Species	1981	1983	1985	1976-80	1981-85
		(million)		(percent)	
Cattle	20.0	21.0	22.1	6.1	2.6
Sheep	18.6	20.0	19.3	2.8	3.3[a]
Goats	13.8	14.1	14.6	4.1	2.0
Camels	2.8	2.8	2.8	3.4	1.2

Source: Information from the Ministry of Agriculture and Natural Resources, Animal Resources Economics Administration (these rates were applied to estimate livestock population for the period 1976-80, and FAO growth-rate estimates were applied for the 1981-85 period).

[a] The growth rate shown here is contrary to the observations in the 1989 International Food Policy Research Institute survey of Northern Kordofan villages, which showed a decreasing rate for the 1981-85 period.

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[5] All tons in this report are metric tons.

Table 26—Growth rates of agricultural components of gross domestic product, Sudan, 1982-87

GDP Component	1982	1983	1984	1985	1986	1987
	(percent change from previous year)					
Agricultural GDP	-7.6	-2.3	-23.5	30.4	2.0	-12.1
Crops	-13.4	-2.6	-21.0	40.6	-3.4	-21.4
Irrigated	26.7	3.1	-6.0	4.9	-4.9	-3.9
Rainfed						
Mechanized	-51.1	1.2	-63.4	345.3	11.2	-59.9
Traditional	-33.6	-17.4	-36.8	75.3	-13.1	-22.3
Livestock	1.0	-4.3	-32.7	19.7	12.8	1.5

Source: Based on data files of the Ministry of Finance and Economic Planning, Khartoum.

periods. Area growth averaged an annual rate of 5.3 percent (Table 28). Average yield, on the other hand, experienced a steady decline from 348 kilograms to 273 kilograms per feddan over the 26-year period at an annual rate of -2.1 percent.

Production growth peaked in 1974-86 at a drought-excluding growth rate of 4.6 percent (Table 28). This occurred mainly as a result of a 6.3 percent growth in cultivated area. Rapid expansion of mechanized farms, particularly in Central and Eastern regions, contributed largely to the record growth. Production from these farms grew at an annual rate of 7.7 percent, mainly due to 8.9 percent growth in area (Table 29).

Growth was much lower when the effect of the 1984 drought was included in the growth estimate. The growth rate for mechanized sorghum production dropped

Table 27—Average production, area, and yield of cereal crops in Sudan, 1961-86

Crop	1961-73		1974-86	
Sorghum				
Production (1,000 metric tons)	1,349	(307)	2,183	(719)
Area (1,000 feddans)	3,885	(791)	8,059	(2,196)
Yield (kilograms/feddan)	348	(43)	273	(55)
Millet				
Production (1,000 metric tons)	328	(72)	394	(106)
Area (1,000 feddans)	1,606	(529)	2,969	(462)
Yield (kilograms/feddan)	218	(52)	136	(40)
Wheat				
Production (1,000 metric tons)	100	(58)	203	(66)
Area (1,000 feddans)	201	(110)	440	(162)
Yield (kilograms/feddan)	520	(103)	484	(91)

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Figures in parentheses are standard deviations of means.

Table 28—Growth rates of production, area, and yield of cereal crops in Sudan, 1961-86

Crop	1961-73	1974-86	1961-86
		(percent)	
Sorghum			
Production	1.8[a]	2.6 (4.6)	3.2 (3.8)
Area	3.4	5.7 (6.3)	5.3 (5.4)
Yield	-1.7	-3.1 (-1.7)	-2.1 (-1.6)
Millet			
Production	2.9	-4.2 (-2.3)	0.8 (1.5)
Area	7.9	2.7 (2.8)	5.1 (5.2)
Yield	-5.0	-6.8 (-5.1)	-4.3 (-3.7)
Wheat			
Production	16.4	-6.9 (-5.3)	6.0 (6.9)
Area	17.8	-9.7 (-7.4)	6.2 (7.4)
Yield	-1.4[b]	2.8 (b)	-0.2 (b)

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Figures in parentheses are drought-free, that is, they exclude the 1984/85 season.

[a] t-values are statistically significant for corresponding growth rates (parameter estimates are at least two times the associated standard error).

[b] Growth rates are not reported for lack of acceptable statistical significance.

to 4.4 percent due to a substantial drop in the rate of yield growth (Table 29). For the nonmechanized areas, the 1984/85 season exacerbated the shortfalls in yield. The only exception was the irrigated sector, which experienced positive growth but, because of its small share, had a marginal impact on overall performance. The overall effect of 1984/85 was a sluggish growth in sorghum production, largely

Table 29—Growth rates of sorghum production, area, and yield in Sudan, by technology, 1961-86

Technology	1961-73	1974-86		1961-86	
		(percent)			
Traditional (rainfed)					
Production	-3.1	-5.5	(-4.1)	-2.2	(-1.6)
Area	-0.01	1.5	(1.7)	1.5	(1.5)
Yield	-2.3	-7.0	(-5.9)	-3.6	(-3.2)
Mechanized (rainfed)					
Production	11.7	4.4	(7.7)	9.6	(10.7)
Area	13.8	8.1	(8.9)	11.5	(11.8)
Yield	-2.1	-3.7	(-1.2)	-1.9	(-1.1)
Irrigated					
Production	1.1	8.0	(7.6)	1.8	(1.6)
Area	1.8	5.7	(5.7)	2.1	(2.0)
Yield	-0.7	2.2	(1.8)	-0.3	(-0.5)

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Figures in parentheses are drought-free, that is, they exclude the 1984/85 season.

attributed to the sharp drop in yield. There were sizable variations in growth performance among the important production regions (Table 30). Regions with better access to water—whether from rain or irrigation—demonstrated a lower drop in yield growth.

Variation in production levels across the subperiods was associated with increased instability. Fluctuations were more pronounced in the 1982-86 period. This is illustrated by comparisons of indices in Table 31. Relative to the normal years of

Table 30—Average growth rates of production, area, and yield of food crops, by main producing provinces, 1974-86

Crop/Province	Region	Production	Area	Yield
			(percent)	
Sorghum				
Kassala	Eastern	3.4	6.1	-2.6
Gezira	Central	2.8	3.4	-0.6
Blue Nile	Central	7.1	8.9	-1.7
Southern Kordofan	Kordofan	a	6.3	-5.8
Millet				
Northern Kordofan	Kordofan	-6.4	1.3	-7.8
Northern Darfur	Darfur	-5.1	1.1	-6.2
Southern Darfur	Darfur	a	6.2	-7.6
Wheat				
Gezira	Central	-17.8	-19.5	a

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Growth estimates include the 1984/85 season.

[a] Growth rates not reported for lack of statistical significance.

Table 31—Indices of production, area, and yield of cereal crops in Sudan, 1974-86

Crop	1974-78	1980-81	1982-83	1984	1985	1986
Sorghum						
Production	100	134	94	55	180	164
Area	100	123	133	121	200	180
Yield	100	107	71	45	90	91
Millet						
Production	100	120	78	38	102	68
Area	100	98	103	111	146	131
Yield	100	185	113	51	104	78
Wheat						
Production	100	69	60	30	77	60
Area	100	62	53	19	58	46
Yield	100	110	111	163	131	132

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Mean levels of production, area, and yield for the three crops in 1974-78 are sorghum—2.0 million metric tons, 6.6 million feddans, 304 kilograms per feddan; millet—418,000 metric tons, 2.8 million feddans, 146 kilograms per feddan; wheat—260,000 metric tons, 616,200 feddans, 421 kilograms per feddan.

1974-78, production of sorghum increased in 1980 and 1981, dropped for the next three years, and recovered strongly in 1985. Fluctuations in production mainly reflect variability in yield.

Millet

Average annual production of millet increased from 328,000 tons in 1961-73 to 394,000 tons in 1974-86 (Table 27). For the whole 26-year period, no significant production trend was established (Table 28). However, the area under millet increased continuously, from 1.6 million feddans in 1961-73 to 3.0 million feddans in 1974-86, at an average annual growth rate of 5.1 percent. Average yields dropped over the same periods from 218 kilograms to 136 kilograms per feddan at a growth rate of −4.3 percent.

The low-growth production path of millet was largely determined by the drought years of the 1980s. Production showed an average growth rate of −4.2 percent in the 1974-86 period. The growth rate improves by 1.9 percent when the 1984/85 season is excluded (Table 28). Area planted grew at a rate of 2.7 percent, but yield recorded a growth of −6.8 percent. Thus, despite an increase in area planted to millet, yield decline overwhelmed the production trend. A large-scale decline in production and yield occurred in the main production areas of Northern Kordofan and Northern Darfur (Table 30).

Production of millet is marked by considerable and increasing year-to-year variations. The greatest source of instability is related to yield variability. The instability measure in Table 32 shows a 3-to-1 ratio between yield and area coefficients.

Wheat

Production of wheat is concentrated in the irrigated schemes, particularly in Gezira. Like that of other irrigated crops, the annual production is governed by an

Table 32—Relative variability in cereal crop production, area, and yield in Sudan, 1961-86

Crop	1961-73	1974-81	1982-86	1961-86
	(coefficients of variation)			
Sorghum				
Production	22.8	25.9	38.6	30.2
Area	15.8	14.1	17.3	15.4
Yield	11.1	10.3	25.6	14.9
Millet				
Production	20.2	27.8	32.2	28.8
Area	14.5	9.6	10.0	15.1
Yield	18.6	18.9	30.6	25.4
Wheat				
Production	14.4	19.1	29.9	41.5
Area	21.4	11.3	35.0	47.5
Yield	19.9	17.8	15.6	19.1

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Computations are based on a general measure of instability developed by Cuddy and Valle (1978).

administrative set of rules on area allocation, water use, and prices. Wheat is grown in winter (*rabi* season) as part of a regular crop-rotation cycle. It usually follows the summer crops of sorghum and groundnuts. The availability of water in the winter months and relative allocation between competing crops, cotton in particular, determine much of its production performance.

Compared with the 1961-73 period, production as well as area reached higher mean levels during 1974-86 (Table 27). Production grew from 100,000 tons to 203,000 tons. Area increased from 201,000 feddans to 440,000 feddans. Average productivity, on the other hand, fell from 520 to 484 kilograms per feddan.

Wheat yield, unlike the yield of rainfed crops, registered positive growth, but not enough to overwhelm the depressing effect of area contraction (Table 28). In fact, area under wheat decreased continuously from 1976 to 1982, recovered in 1983 due to the addition of new areas, but dropped to a record low in 1984. Production of wheat was banned in the Gezira scheme in 1984 because of the low water level of the Blue Nile, which feeds two-thirds of the irrigated areas.

Records of growth patterns and performance among the three cereal crops show some notable experiences (Tables 27-32). First, production growth has been largely based on expansion of area. In the case of sorghum, this expansion has been accompanied by rapid mechanization. For wheat, area contraction was the main factor for poor performance in the 1974-86 period. Second, the contribution of productivity to growth of production has been minimal. In fact, production growth for most crops has occurred in an environment of declining productivity, particularly for those crops that are grown in the nonmechanized rainfed system. Occurrences of droughts exacerbate the poor yield base of these crops. Finally, production levels are associated with high relative variances. Sources of fluctuation appear to be climate-based for rainfed crops, such as sorghum and millet, and policy-induced in the case of wheat.

Rainfall Patterns in the Main Production Areas

Recorded rainfall data for 1960-86 covering selected areas located between 10° 00′ and 14° 20′ north latitudes and between 24° 20′ and 35° 24′ east longitudes are examined in this section. The sampled areas cut across the regions of Darfur (El Fasher and Nyala) and Kordofan (En Nahud and Kadugli), and the Central (Kosti, Sennar, and Roseries) and Eastern (Gedaref) regions (Table 33). Kadugli, Kosti, Sennar, Roseries, and Gedaref are important sorghum-production areas. Millet is an important crop in the west, particularly in Darfur and Northern Kordofan Province.

Mean total precipitation increases southward, and for localities on the same latitude, rainfall tends to increase eastward. Similar patterns are observed for the number of rainy days (Table 33). For most of the sample stations, the mean levels for both total precipitation and number of rainy days show a declining pattern over the 27-year period. The 10-year mean of annual precipitation in the 1970s was below the 10-year mean of the 1960s in six of the eight sampled sites. The mean levels of the early 1980s were far below those of the 1960s in all the sites. There were also fewer rainy days in the 1970s and even fewer in the early 1980s as compared with the 1960s (Table 34). The decline in rainfall totals appears to be

Table 33—Mean rainfall and rainy days at selected stations, 1960-86

Region/Site	Province	Latitude	Longitude	Mean Rainfall	Coefficient of Variation	Mean Rainy Days
				(millimeters)		
Central						
Sennar	Blue Nile	13°33′N	33°37′E	427.0	0.27	34.6
Kosti	White Nile	13°02′N	32°40′E	355.6	0.24	41.3
Roseries	Blue Nile	11°51′N	34°24′E	646.9	0.14	46.7
Darfur						
El Fasher	Northern Darfur	13°38′N	25°20′E	220.9	0.29	29.0
Nyala	Southern Darfur	12°04′N	24°53′E	417.3	0.20	38.6
Eastern						
Gedaref	Kassala	14°02′N	35°24′E	595.9	0.17	54.2
Kordofan						
En Nahud	Northern Kordofan	12°40′N	28°26′E	352.3	0.27	39.2
Kadugli	Southern Kordofan	10°00′N	29°43′E	681.8	0.20	61.4

Source: Computed from raw data from the Sudan Meteorological Department, Khartoum.

associated with fewer rainy days. Such a pattern could contribute to the greater propensity for drought to occur in areas where soils have low water-holding capacity.

The annual distribution of rainfall shows that most of the rains occur in the months between June and September. The months of July and August represent the peak months and account for a large share of total precipitation. Ibrahim's (1984) findings on Northern Darfur also reveal that annual precipitation curves are steeper toward the north, that is, precipitation tends to be concentrated heavily in the wet months, particularly in August.

Temporal variations in total precipitation are notable among the sample sites. The coefficients of variation around estimated trends vary between 0.29 in El Fasher and 0.14 in Roseries (Table 33). El Fasher (0.29), En Nahud (0.27), and Kosti (0.24) show relatively high variability. El-Tom's (1986) findings also confirm considerable rainfall fluctuation in Khartoum, El Fasher, and El Obeid. Relative variation is more prominent in the arid and semi-arid climatic zones, especially in the west.

The year-to-year fluctuations in rainfall increased considerably in the 1980s as compared with earlier decades within these sample areas. The coefficients of variation increased from a low of 0.13 in the 1960s to 0.33 in the 1970s and 0.34 in the 1980s in El Fasher. In En Nahud, it progressed from 0.18 to 0.23 and 0.45 in the three decades, respectively. A similar pattern was observed in Kosti (0.18 in the 1960s, 0.17 in the 1970s, and 0.32 in the 1980s), Nyala (0.18 in the 1960s, 0.16 in the 1970s, and 0.29 in the 1980s), and Roseries (0.11 in the 1960s to 0.17 in the 1970s and 0.18 in the 1980s). The 1980s were definitely marked by large fluctuations that were largely reflective of variations in the number of rainy days.

There are important issues of interest that are not evident in the studies discussed above. First, is the shift in the climatic pattern part of a cyclical phenomenon? Second, how are low rainfall levels compatible with growth of food crops (by

Table 34—Distribution of mean rainfall, rainy days, and rain per day at selected stations, 1960-86

Region/Site	Mean Annual Rainfall			Mean Rainy Days			Mean Rain per Day		
	1960-69	1970-79	1980-86	1960-69	1970-79	1980-85	1960-69	1970-79	1980-86
		(millimeters)						(millimeters)	
Central									
Sennar	461.7	446.2	315.0	37.9	32.3	32.0	12.2	13.8	9.8
Kosti	372.8	391.4	273.0	47.7	41.4	31.0	7.8	9.5	8.8
Roseries	727.6	665.5	504.9	59.9	44.6	29.4	12.1	14.9	17.2
Darfur									
El Fasher	271.9	203.0	168.6	38.9	26.4	18.6	7.0	7.7	9.1
Nyala	470.1	414.4	367.5	42.8	38.7	33.2	11.0	10.6	11.1
Eastern									
Gedaref	579.1	623.2	543.5	49.7	59.7	50.6	11.7	10.4	10.7
Kordofan									
En Nahud	373.0	349.7	337.9	44.6	37.6	32.8	8.4	9.3	10.3
Kadugli	748.0	673.5	584.3	58.7	67.4	56.8	12.7	10.0	10.3

Source: Computed from raw data from the Sudan Meteorological Department, Khartoum.

type and variety) across the country's production zones? Finally, to what extent does the spread of annual rainfall match the optimal growth cycle of crops? These questions may be relevant in the context of the search for technological innovation and commodity priorities in the drought-prone regions.

Drought-Production Relationships

The preceding discussion on the performance of cereal crop production in the 1980s highlights the adverse effects of drought on growth components, particularly yields. The effect of drought on cereal production is largely mediated through the short-run impact on yield. In this section, an attempt is made to isolate the systematic impact of rainfall through simple supply functions defined as

$$Q_{it} = \alpha_0 + \alpha_1 \, RAIN_t + \alpha_2 \, (RAIN_t)^2 + \alpha_3 \, P_{it-1} + \alpha_4 \, P_{jt-1} + \alpha_5 \, T + u_t, \qquad (4)$$

where

Q_{it} = production or yield of crop i in period t,
$RAIN_t$ = rainfall index in period t,
P_{it-1} = own deflated price in period t−1,
P_{jt-1} = price of competing crop j in period t−1,
T = time trend,
u_t = random error term in period t, and
α_0, α_1, α_2, α_3, α_4, and α_5 are parameters to be estimated.

Total annual rainfall for selected sites weighted by respective production shares was used for aggregate cereals and sorghum. In the case of millet, however, the relevant measure was total rainfall in the months of June, July, and August. Weights were derived from production records of the 1974-86 period. Prices are weighted regional wholesale prices. The gross national product (GNP) deflator was used to deflate the prices. Price terms were dropped from yield equations due to poor response. No price terms were included in millet equations due to lack of complete series. All the variables were in natural logarithms. The choice of the functional form was based on a preliminary evaluation of the values of the log-likelihood function and the correlation coefficients between predicted and observed values of the dependent variables for alternative functional forms.

The rainfall effect on production as well as yield is hypothesized to be positive but to diminish at the margin. The square term of rainfall in the supply equation is expected to take a negative sign. The time trend is used as a proxy for technology, especially mechanization, and increased labor use.

Table 35 presents the parameter estimates and associated t-statistics. The coefficients for the rainfall term are significant (t-ratios equal to or greater than 2.0) in 13 out of 17 cases. Rainfall has a significant systematic impact on production responses. The squared terms are also significant, and the signs suggest that rainfall does affect production but at a diminishing rate. The trend variable has a significant impact on yields for all-Sudan cereals, sorghum, and millet. Since adding price could not diminish the effect of the trend variable, factors other than rainfall and

Table 35—Parameter estimates of yield and production response equations for cereal crops

Cereal	Region	Period	Dependent Variable[a]	Independent Variables					Constant	Log LF[b]	Degrees of Freedom
				$RAIN_t$	$RAINSQ_t$	$TREND_t$	$OPRC_{t-1}$	$CPRC_{t-1}$			
Cereals[c]	Sudan	1969-76	CRYLD	13.63 (2.48)	-1.10 (-2.32)	-0.02 (-2.85)	...	...	-4.93 (-0.26)	-82.94	14
			CRPRD	16.14 (1.82)	-1.30 (-1.70)	0.04 (4.11)	...	...	-116.41 (-3.80)	-131.86	14
Sorghum	Sudan	1969-86	SSRYD	17.59 (2.16)	-1.41 (-2.05)	-0.02 (-2.32)	...	...	-19.20 (-0.70)	-81.79	13
			SSRPD	33.12 (2.15)	-2.71 (-2.07)	...	0.52 (3.26)	-0.33 (-2.62)	-83.85 (-2.07)	-124.53	12
			SSRPD	24.74 (1.82)	-1.99 (-1.73)	0.05 (4.33)	...	...	-161.82 (-3.53)	-123.40	13
	Eastern (Gedaref)	1973-86	GSRYD	28.85 (3.92)	-2.21 (-3.38)	0.01 (0.21)	...	...	-88.44 (-3.44)	-65.88	9
			GSRPD	42.92 (3.68)	-3.34 (-3.58)	0.06 (2.93)	...	...	-136.23 (-3.72)	-81.53	9
			GSRPD	45.15 (3.93)	-3.53 (-3.84)	...	0.33 (1.35)	-0.21 (-1.10)	-137.93 (-3.86)	-82.68	8
	Central (Blue Nile)	1973-86	BNSYD	16.02 (2.34)	-1.18 (-2.18)	0.03 (1.54)	...	...	-51.05 (-2.38)	-66.74	8
			BNSPD	21.83 (1.65)	-1.16 (-1.53)	0.15 (3.83)	...	...	-79.62 (-1.91)	-80.74	9
			BNSPD	31.12 (2.19)	-2.38 (-2.12)	...	0.75 (2.12)	-0.48 (-1.72)	-95.79 (-2.13)	-82.49	8
Millet	Sudan	1969-86	SMLYD	10.61 (3.08)	-1.23 (-2.97)	-0.05 (-2.11)	...	...	-14.10 (-1.90)	-86.86	14
			SMLPD	12.56 (2.80)	-1.44 (-2.68)	-0.002 (0.17)	...	...	-21.60 (-2.26)	-104.96	14
	Kordofan (Northern)	1973-86	KMLYD	22.07 (2.98)	-2.02 (-2.84)	-0.04 (-1.65)	...	...	32.30 (0.56)	-64.71	10
			KMLPD	20.29 (2.44)	-1.85 (-2.33)	-0.03 (-1.42)	...	...	17.27 (0.32)	-68.93	10

(continued)

Table 35—Continued

Cereal	Region	Period	Dependent Variable[a]	Independent Variables					Constant	Log LF[b]	Degrees of Freedom
				$RAIN_t$	$RAINSQ_t$	$TREND_t$	$OPRC_{t-1}$	$CPRC_{t-1}$			
Millet	Darfur (Southern)	1973-76	DMLYD	9.78 (2.66)	−0.86 (−2.46)	−0.05 (−2.98)	. . .	. . .	85.94 (2.16)	−65.39	10
			DMLPD	4.68 (1.19)	−0.38 (−1.05)	0.004 (0.10)	. . .	. . .	−17.46 (−0.22)	−66.46	10

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Figures in parentheses are t-values.

[a] Coefficients are adjusted for autocorrelation of error terms using Cochrane-Orcutt procedure.

[b] Log LF is the value of the log-likelihood function at convergence.

[c] Cereals include sorghum and millet only.

Definitions of variables:

CRYLD = Sudan cereal yield per feddan in kilograms;
CRPRD = Sudan cereal production in 1,000 metric tons;
SSRYD = Sudan sorghum yield per feddan in kilograms;
SSRPD = Sudan sorghum production in 1,000 metric tons;
GSRYD = Gedaref sorghum yield per feddan in kilograms;
GSRPD = Gedaref sorghum production in 1,000 metric tons;
BNSYD = Blue Nile sorghum yield per feddan in kilograms;
BNSPD = Blue Nile sorghum production in 1,000 metric tons;
SMLYD = Sudan millet yield per feddan in kilograms;
SMLPD = Sudan millet production in 1,000 metric tons;
KMLYD = Northern Kordofan millet yield per feddan in kilograms;
KMLPD = Northern Kordofan millet production in 1,000 metric tons;
DMLYD = Southern Darfur millet yield per feddan in kilograms;
DMLPD = Southern Darfur millet production in 1,000 metric tons;
$RAIN_t$ = rainfall index in period t;
$RAINSQ_t$ = rainfall squared;
$OPRC_{t-1}$ = own price in period t−1; and
$CPRC_{t-1}$ = competing price in period t−1.

price should explain the observed trend. In the case of production response, however, the effect of trend diminishes when price variables are included.

The corresponding elasticities evaluated at sample means are given in Table 36. The elasticities measure the percentage change in production or yield for a 10 percent change in rainfall, adjusted for curvature effect. The results suggest that a 10.0 percent drop in annual rainfall results in a 5.0 percent and 7.3 percent drop in cereal and sorghum production, respectively. The corresponding drops in yield are 3.7 and 5.4 percent. The elasticities are smaller for aggregate millet: 1.6 percent for yield and 3.0 percent for production. Sorghum is more sensitive than millet to rainfall changes.

The elasticities also suggest that regional/provincial production is more sensitive to rainfall fluctuation than is aggregate production. Sorghum in Blue Nile Province, for example, shows a 10.4 percent drop in yield compared with 5.4 percent for aggregate sorghum, and a 15.2 percent drop in production compared with 7.3 percent for the aggregate. The greater response at the regional level also holds for millet; compare 5.3 percent for millet yield in Northern Kordofan to 1.6 percent for aggregate millet yield. There are also significant interregional differences in elasticities for the same crop.

The effects of price changes on sorghum production can be read directly from Table 35. A 10.0 percent increase in the price of sorghum results in a 5.2 percent increase in production. The increase is 7.5 percent in the Blue Nile Province. A rise in the relative price of sesame encourages farmers to move out from sorghum production; a 10.0 percent increase in the price of sesame leads to a 3.3 percent cut in aggregate sorghum production. The response is again greater in the Blue Nile area, where farmers cut sorghum production by 4.8 percent for a 10.0 percent increase in the relative price of sesame.

Table 36—Response of yield and production of rainfed cereal crops to a 10 percent change in rainfall index

Crop	Region	Response Variable	Rainfall Effect
			(percent)
Cereals	Sudan	Yield	3.7
		Production	5.0
Sorghum	Sudan	Yield	5.4
		Production	7.3
	Eastern (Gedaref)	Yield	4.9
		Production	1.4
	Central (Blue Nile)	Yield	10.4
		Production	15.2
Millet	Sudan	Yield	1.6
		Production	3.0
	Kordofan (Northern)	Yield	5.3
		Production	5.6
	Darfur (Southern)	Yield	3.2
		Production	5.0

Source: Calculated from the results in Table 26.

5

PRICES AND MARKET DISCONNECTIONS DURING FAMINES

It is of central importance for government policymakers to have a comprehensive understanding of the functioning of markets during food-shortage situations caused by domestic production decline. Understanding of the production-price relationship provides a key input into policies regarding interregional trade, stockholding, and imports (including food aid). The following assessment of market behavior during the past two decades pulls together some critical facts considered as inputs for informed decisionmaking related to such policies and government interventions.

The focus of this analysis will be on presenting factual information on price development and establishing factors that contribute to such behavior. The main components of price development are related to the evolution of absolute and relative price movements, seasonality of prices, and regional price spread. The shifts in relative prices between cereals and cash crops and between cereals and livestock are important indicators of the erosion of purchasing power during food-shortage situations. The pattern of seasonality of prices, which often follows local production patterns, may change during a period of drought, giving rise to different timing of sales and amplitude of price changes. The extent to which deviations from normal patterns occur indicates the potential complementary role of other sources of supply—imports, stocks, and food aid—in smoothing intrayear variations. Differences in interregional price variations hint at the key role of better market integration through improved rural infrastructure. The short-term effects of production and food availability declines on prices and terms of trade hint at the critical need for a very rapid mobilization of resources and programs to cope with the short-term food-security problem of the poor when drought hits.

Evolution of Food Prices

Price Levels

Cereal prices rose steadily in the early 1980s, peaked in 1984, and then dropped in the 1985 and 1986 seasons (Table 37). Between 1982/83 and 1984, cereal prices increased threefold. The real price in the 1985/86 season was at the level prevailing in the 1970s (Figure 8).

A rapid price increase occurred in the months preceding the harvest season of 1984. The nominal price of sorghum in the El Obeid market in the west, for example, increased from SD£32 to SD£57 and then to SD£137 per 100 kilograms in the months of January, July, and October 1984, respectively (Table 38). The price was nearly five times higher in October 1984 than in the same month in 1983.

Table 37—Undeflated average wholesale prices for crops and cattle in selected markets, 1974-86

Period	All-Sudan Cereals[a]	Sorghum		Millet		Sesame	Cattle	
		Gedaref	El Obeid	Nyala	El Obeid	El Obeid	Nyala	El Obeid
	(SD£/100 kilograms)						(SD£/head)	
1974-78	3.71	2.94	5.07	6.71	n.a.	12.36	36.78	40.16
1980-81	14.04	9.66	18.85	36.79	n.a.	35.11	161.21	172.92
1982-83	35.81	29.21	36.34	71.23	51.17	87.50	277.71	272.00
1984	117.79	98.58	108.63	217.13	141.18	157.80	187.71	204.50
1985	57.53	53.50	80.00	88.70	66.77	189.09	672.33	645.67
1986	31.97	28.35	39.78	71.85	60.33	172.98	1,504.00	1,326.50

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, 1985); MANR, *Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, 1987); and MANR, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

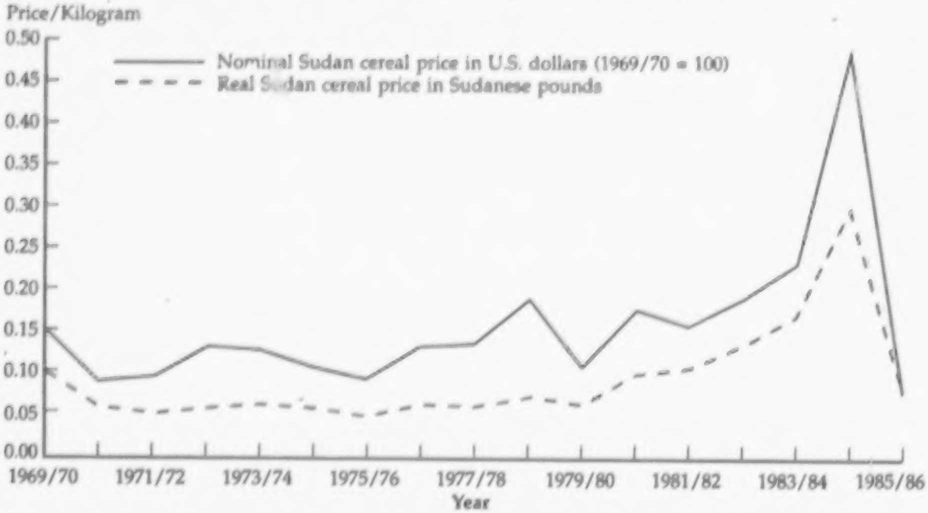
Notes: Gedaref is in the Eastern Region, El Obeid is in Kordofan Region, and Nyala is in Darfur Region; n.a. means not available.

[a] Weighted average of Gedaref sorghum and Nyala millet wholesale prices.

Cereal prices continued to increase and stayed at high levels until the harvest of 1985. By the end of the 1985 harvest, prices had dropped to as low as 30 percent of the 1984 average.

The strong association of production and price variability in cereals in the short run is also evident in the case of sesame. Its price increased in 1984, albeit modestly compared with cereal crops, and continued to rise during the 1985 season because of the poor harvest.

Figure 8—Cereal real price versus nominal price in Sudan, 1969/70–1985/86



Source: Computed from price series data compiled from various publications of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics.

Table 38—Average monthly wholesale prices for sorghum, millet, sesame, and cattle in selected markets, October 1983-January 1986

	Sorghum		Millet	Sesame	Cattle	
Period	Gedaref	El Obeid	El Obeid	El Obeid	Nyala	El Obeid
	(SD£/100 kilograms)				(SD£/head)	
October 1983	24.95	29.32	48.23	110.98	336	318
January 1984	26.94	32.24	51.22	94.50	287	296
April 1984	32.81	40.98	60.94	. . .	. . .	. . .
July 1984	37.85	56.97	n.a.	94.02	254	292
October 1984	102.08	136.68	n.a.	126.63	142	172
January 1985	107.21	122.70	146.35	197.86	241	121
July 1985	119.02	151.03	151.57	190.57	185	368
October 1985	63.91	103.22	n.a.	191.02	395	473
January 1986	36.17	40.55	72.93	196.00	787	672

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, *1985); MANR, Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, *1987); and MANR, Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, *1988).*

Note: Gedaref is in the Eastern Region, El Obeid is in Kordofan Region, and Nyala is in Darfur Region.

The picture is different in the case of livestock. Prices of livestock dropped significantly in 1984, particularly in the months that coincided with the peak rise in cereal prices. In Nyala market in the west, the price of cattle per head dropped from SD£254 in July 1984 to SD£142 in October 1984. The price reached SD£121 in El Obeid market in January 1985. In rural markets, the price drop was much greater. For example, in Bara market in Northern Kordofan, the price of cattle was down to SD£48 per head in April 1985. Prices recovered strongly, however, and continued to rise at a much faster rate after mid-1985. This dramatic price increase slowed recovery, particularly among those who used to own small herds.

The patterns of these price movements remains unchanged even when they are deflated to account for changes in the general price level. It is evident that 1984, which witnessed large increases in cereal prices, was also a year of large increases over the general price level of 1983. The increasing trends in the general price level suggest that real commodity prices were lower than nominal prices but followed a path similar to the movement of nominal prices.

Relative Price Movements

For farm households that grow cash crops or produce livestock, their purchasing power and ability to acquire staple foods is largely determined by the terms of trade between food and the households' farm produce for the market. Similarly, for rural wage earners, the ability to acquire food depends considerably on the level of food prices versus the (cash) wage rate. Data on rural wage rates are unfortunately not available. Therefore, the following assessment concentrates on the terms of trade between staple foods, on the one hand, and cash crops and livestock, on the other.

The relative price movements between sorghum and the two main cash crops—sesame and groundnuts—are shown in Table 39. The evolution of these relative prices reveals that the terms of trade deteriorated dramatically during the 1984-85 food shortage. For example, the terms of trade between sesame and sorghum in the Central and Eastern regions fell from 0.73 to 0.32 between 1974-78 and 1984. This suggests that the same amount of sesame could buy less than half (44 percent) as much sorghum in 1984-85 as in the 1974-78 period. Similarly in Kordofan, the terms of trade declined to 0.34 in 1984 from 0.56 in 1974-78. The deterioration was much greater in the case of groundnuts. The price of groundnuts in terms of sorghum dropped from 1.1 in 1974-78 to 0.54 in 1984 in Kordofan, that is, the same amount of groundnuts could buy only half as much sorghum in the drought year of 1984. While cash crops tended to provide a reasonably reliable income source for farmers in normal years, their contribution to real income in food-crisis years, such as 1984-85, rapidly deteriorated.

The evolution of the terms of trade between cattle and sorghum and between goats and sorghum is shown in Table 40. Goats are the most commonly owned animals and provide an important source of income, particularly among the low-income households. Cattle are the most preferred animals, particularly among pastoralists who are settled south of 13° north latitude.

The price of cattle in terms of sorghum continuously deteriorated over the years until 1985, when there was a turnaround. The terms of trade were dramatically low in 1984 compared with the previous years. Cattle producers could buy only about one-tenth of the sorghum that they could in 1979 per head of cattle. In other words, producers had to provide about 8 to 10 times more cattle to acquire the same amount of sorghum in return in 1984 as in 1979. This was more or less consistently the case in central Sudan as well as in Kordofan and Darfur regions. The deterioration in the terms of trade between cereals and small ruminants was comparatively smaller.

Table 39—Terms of trade between cash crops and staple foods, as ratio of price indices, 1974-85

	Central/Eastern Regions	Kordofan Region		Darfur Region
Period	Sesame Price Index/Sorghum Price Index	Groundnut Price Index/Sorghum Price Index	Sesame Price Index/Sorghum Price Index	Sesame Price Index/Millet Price Index
		(Index: 1979 = 1.00)		
1974-78	0.73	1.05	0.56	1.09
1980-81	0.75	1.14	0.43	0.49
1982-83	0.65	1.01	0.58	0.64
1984	0.32	0.54	0.34	0.45
1985	0.96	2.13	0.96	1.01

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, 1985); MANR, *Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, 1987); and MANR, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

Table 40—Terms of trade between livestock and sorghum, as ratio of price indices, 1974-85

Period	Central/Eastern Regions: Cattle Price Index/ Sorghum Price Index	Central/Eastern Regions: Goat Price Index/ Sorghum Price Index	Kordofan Region: Cattle Price Index/ Sorghum Price Index	Kordofan Region: Goat Price Index/ Sorghum Price Index	Darfur Region: Cattle Price Index/ Sorghum Price Index	Darfur Region: Goat Price Index/ Sorghum Price Index
			(Index: 1979 = 1.00)			
1974-78	0.63	0.96	0.47	0.61	0.85	0.93
1980-81	0.60	0.63	0.46	0.55	0.51	0.60
1982-83	0.32	. . .	0.31	0.47	0.37	0.47
1984	0.12	0.14	0.09	0.17	0.11	. . .
1985	0.68	0.67	1.06	1.02	1.39	. . .

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, 1985); MANR, *Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, 1987); and MANR, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

Seasonality of Prices

Regular intrayear variations in cereal prices follow a unimodal distribution in conformity with the annual production cycle. In the case of sorghum, prices start from seasonal lows in December as the new harvest comes into the markets. Prices show modest rises in the consecutive months between January and May, then faster growth in the wet-season months from July to October. The months between July and October represent high points, with the peak in October (Table 41). The seasonal price spread averages a monthly growth rate of 2 percent.

Table 41—Seasonal price indices for sorghum, millet, and cattle in selected markets, 1980-82

Commodity/ Market	January	April	July	October	Highest Month	Lowest Month	Seasonal Increment
		(percent)					(percent)
Sorghum							
Gedaref	94.5	99.2	102.6	111.4	October	December	18.7
El Obeid	93.1	99.2	101.3	109.4	October	January	16.3
Millet							
El Obeid	97.3	98.0	97.7	106.6	November	n.a.	16.3
Cattle							
Nyala	102.4	104.2	99.8	92.3	March	October	16.5

Source: Sudan, Ministry of Agriculture and Natural Resources, *Seasonal Movements in Sudan's Agricultural Commodity Prices* (Khartoum: MANR, 1988).

Notes: The indices were derived using 12-month centered moving average techniques applied to a multiplicative model. n.a. means not available.

The months between December 1984 and October 1985 exhibited a marked departure from regular seasonal behavior. The price of sorghum rose rapidly in the postharvest months, shifting the seasonal high points to the months between February and June. In fact, record high prices were experienced during these months. The price then dropped unseasonably low between August and October 1985. The unseasonable price decline suggests revised expectations on the part of traders in anticipation of a good harvest in 1985 or the injection of new supply into the markets or both. In addition to shifts in the high and low months, the period witnessed an average monthly growth of 10 percent in price. The seasonal amplitude was dramatic compared with the regular seasonal increment of 2 percent a month.

Intrayear variability in cattle prices is influenced by the north-south movements of cattle-herding nomads. Sales of cattle begin to rise in July as these nomads move into the vicinity of markets. Trading activity peaks in the months between August and October, and these three months account for nearly 40 percent of annual sales. Sales begin to fall off after October as the nomads return southward. Trading in the months between November and January accounts for 25 percent of annual sales. The period of lowest trading activity starts in February and continues until June.

Monthly prices of cattle tend to follow the seasonal pattern of availability. The price in the Nyala market begins to drop in July and stays at seasonal lows between August and November. The price starts to rise in December and continues at a high level until July (Table 41). On average, the price increases 16 percent from the seasonal low in October.

The 1984/85 cattle prices in Nyala showed two periods of seasonal lows; the first covered September through November and the second was from March through June (Table 42). The second period coincided with the period of the failed

Table 42—Average monthly prices for cattle at Nyala and Bara markets, 1984/85

Year/Month	Nyala	Bara
	(SD£/head)	
1984		
July	254	203
August	336	188
September	145	189
October	142	143
November	125	116
December	182	89
1985		
January	241	95
February	258	83
March	151	58
April	155	48
May	129	62
June	128	73

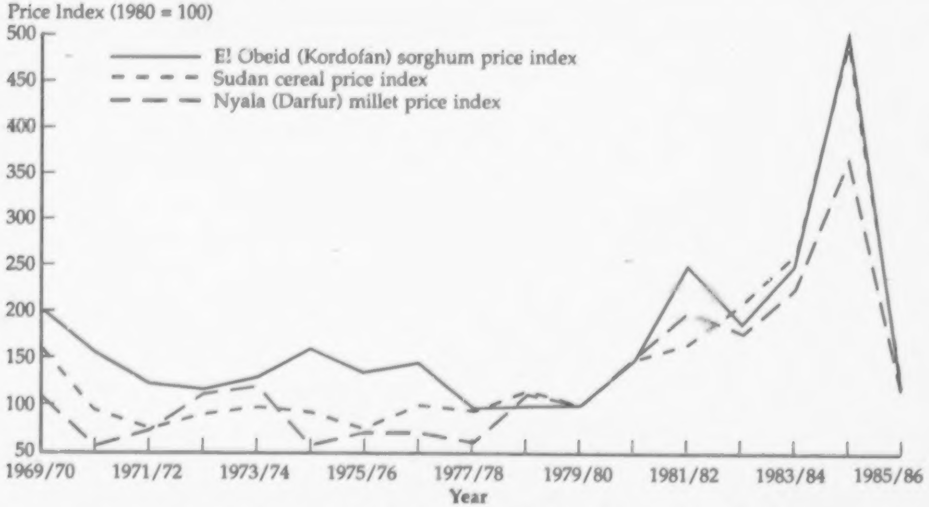
Source: Based on data files of the Relief and Rehabilitation Commission, Khartoum.
Note: Nyala is in Southern Darfur Province; Bara is in Northern Kordofan Province.

1984 harvest and is indicative of the presence of nomads and a large entry of livestock into the market. A more dramatic pattern was, in fact, evidenced in a town market in Bara district in Northern Kordofan, where the price decreased continuously from October 1984 to April 1985. This district typifies areas hard hit by the drought and poorly connected to regional markets.

Regional Market Disconnection

The price index for cereals for the whole country (computed as a weighted average using production shares by region as weights for the prices prevailing in the regions) is contrasted with the local price development in Kordofan and Darfur regions in Figure 9. It reveals that, while many wide differences prevailed between the regions when prices were not excessively high in the 1970s, the general price movement during the food crisis in 1984-85 was apparently spread all over the country. However, similar relative movements mean quite different absolute movements in price levels across regions. This is highlighted by the evolution of the interregional price differences of foodgrains in the case of sorghum. In the 1980s, sorghum prices in Kordofan tended to be 20-25 percent higher than in the eastern sorghum-producing area (Gedaref), and prices in Darfur tended to be more than two times those in Gedaref, while they exceeded Kordofan prices by about 80

Figure 9—Price indices for Kordofan sorghum, Darfur millet, and Sudan cereals, 1969/70–1985/86



Sources: Computed from price series data in Sudan, Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970–1984* (Khartoum: MANR, 1985); *Agricultural Commodity Prices, 1985 Summary* (Khartoum: MANR, 1986); and *Agricultural Commodity Prices, 1986 Summary* (Khartoum: MANR, 1987).

percent (see price ratios after 1982/83 in Table 43). Nevertheless, price wedges between regions appear lower in the 1980s than in the 1970s. Thus, overall market integration may have improved.

A statistical model based on the work of Ravallion (1986) and Timmer (1974) is applied to examine some elements of market integration in grain and livestock markets. The model postulates that changes in local market prices are caused by a change in the spatial margin between local and reference markets, a change in the temporal margin in the reference market, the level of price in the reference market, and local specific factors. The specific equation chosen for estimation is

$$P_{it} = \alpha_i P_{it-1} + \beta_i (R_t - R_{t-1}) + \theta_i R_{t-1} + \Phi_i D85 + \underset{\sim}{\Gamma}\, \underset{\sim}{X} + U_{it}, \qquad (5)$$

where

P_{it} = monthly wholesale price in market i in period t,
R_t = reference market monthly wholesale price in period t,
D85 = dummy variable (1 for month in 1984-85; 0 otherwise),
$\underset{\sim}{X}$ = vector of local specific market-conditioning factor, and
U_{it} = random error term in market i in period t.

Table 43—Interregional wholesale price differences for sorghum, 1969/70-1985/86

	Sorghum		
Season	**Kordofan/Central Ratio**	**Darfur/Central Ratio**	**Darfur/Kordofan Ratio**
	(ratio of deflated prices per kilogram)		
1969/70	1.72	1.55	0.90
1970/71	2.08	1.24	0.60
1971/72	2.84	2.48	0.87
1972/73	2.66	2.17	0.81
1973/74	2.11	3.74	1.77
1974/75	2.07	1.35	0.65
1975/76	2.59	4.12	1.59
1976/77	1.90	4.37	2.30
1977/78	1.27	2.73	2.15
1978/79	1.40	2.47	1.77
1979/80	1.56	4.01	2.57
1980/81	1.56	2.95	1.88
1981/82	2.45	3.75	1.53
1982/83	1.20	2.13	1.78
1983/84	1.27	2.26	1.78
1984/85	1.31	. . .	. . .
1985/86	1.35	. . .	. . .

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, 1985); MANR, *Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, 1987); and MANR, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

The parameter β_i measures the proportional change in the local price caused by a change in the temporal margin in the reference market. A sizable positive value indicates that local prices track with movements in reference market prices, that is, traders monitor changes in reference market prices and adjust local prices accordingly. θ_i measures the influence of the reference market price level (R) on local prices. An increase in the price level may induce local traders to adjust accordingly, particularly in an environment experiencing rapidly increasing prices. Φ_i captures the effects of unseasonal price movements in the 1984-85 period. The vector Γ captures the proportional contribution of factors specific to local price changes.

It is plausible to assume that in the Sudan case the principal regional markets exhibit marked long-term price relationships. A study in Darfur, for example, concludes that the informal market information network among traders is very strong (Darfur Regional Government 1988). The existence of such communication flows suggests that the β_i coefficient may be close to 1, that is, there is a neutral proportional change. But a high β_i may simply reflect the effect of general economic and market forces that show up in apparent market integration (similar to the argument applicable to the coefficient of correlation measure). It may be possible, however, that traders may fail to connect markets through commodity flows in the short run. Therefore, Timmer's indirect but more general measure of market integration is invoked here. It is defined as the ratio of the local market coefficient (α_i) to the reference market coefficient (θ_i), that is,

$$\text{Index of Market Connection (IMC)} = \alpha_i/\theta_i. \tag{6}$$

An IMC greater than 1 indicates poor connection across markets. The relative contributions of local price history are the primary factors in the current level of local prices. An extreme case where the IMC is ∞ implies that markets are segmented ($\theta = 0$). An IMC of less than 1 implies a high degree of market connection. The IMC indicates greater connection as it approaches zero, and when IMC = 0, it suggests that changes in reference market prices are fully reflected in local prices in the short run ($\theta = 1$ and $\alpha_i = 0$).

In order to test the extent of market integration in sorghum and cattle markets, four principal regional markets were selected—Nyala in Darfur Region, El Obeid in Kordofan Region, Omdurman in Central Region, and Gedaref in Eastern Region. Omdurman is the main terminal market for cattle. Large supplies of cattle come from the western regions through the Nyala and El Obeid markets. Gedaref is both the main producer and the main market for sorghum. Even though El Obeid market is largely supplied from the surrounding areas, particularly Southern Kordofan Province, there is sizable competition for trading between the regions.

Changes from month to month in the price of cattle in Nyala and El Obeid were related to Omdurman monthly prices for the period 1981-86. El Obeid market was also used as the reference for the Nyala market. El Obeid sorghum wholesale prices were also related to Gedaref prices for the 1982-86 period. A choice of one month as a time interval is considered a reasonable span for the flow of information and commodities in Sudan's context. This assumption may need to be relaxed for cattle. All the variables are in logarithms, following the tradition of previous work. The parameter estimates of equation (5) are given in Table 44. A summary of measures of integration is in Table 45.

Table 44—Regression coefficients for tests of regional market integration

Commodity	Regional Market	Reference Market	Independent Variables[a]			D85	Constant	LLF	DW	DF
			P_{it-1}	$R_t - R_{t-1}$	R_{t-1}					
Sorghum *(feterita)*	El Obeid	Gedaref	0.55 (4.97)	1.08 (18.45)	0.45 (3.64)	0.04 (0.72)	0.06 (0.47)	44.26	1.93	55
Cattle	El Obeid	Omdurman	0.72 (8.22)	0.78 (12.08)	0.24 (2.31)	. . .	0.15 (0.48)	-403.82	2.07	68
	Nyala	Omdurman	0.75 (8.62)	0.73 (8.05)	0.20 (1.67)	. . .	0.21 (0.49)	-424.81	2.22	68
	Nyala	El Obeid	0.43 (3.82)	0.95 (12.78)	0.60 (4.54)	. . .	-0.17 (-0.07)	-410.70	2.17	68

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Marketing Section, Khartoum.
Note: Figures in parentheses are t-values.

[a] P_{it} = monthly wholesale price in market i in period t, and
R_t = reference market monthly wholesale price in period t.

Table 45—Index of market integration for sorghum and cattle regional markets, 1982-86

Commodity	Regional Market	Reference Market	$\hat{\beta}_i$	IMC
Sorghum	El Obeid	Gedaref	1.08	1.22
Cattle	El Obeid	Omdurman	0.78	2.98
	Nyala	Omdurman	0.73	3.68
	Nyala	El Obeid	0.95	0.71

Source: Computed from regression coefficients in Table 44.
Note: $\hat{\beta}_i$ represents a measure of the proportional change in the local price caused by a change in the temporal margin in the reference market. IMC (index of market connection) represents the ratio of the local market coefficient (α_i) to the reference market coefficient (θ_i).

The statistical significance of the β_i and θ_i coefficients suggests that commodity markets are not segmented. In fact, the high β_i coefficients for sorghum and cattle show that the regional markets in the west have a strong long-term integration with the principal markets in the Central and Eastern regions. Inclusion of dummy variables for the 1984-85 months had little impact on the stability of the coefficient estimates. The price effect of 1984 was nonlocalized and did not have an impact on overall market integration.

Traders have a well-functioning information network for following price developments in distant regional markets. Such an information flow is not, however, complemented by strong connections in the short term. The IMC ratios are greater than 1 for all markets, except those between Nyala and El Obeid. The connections are particularly poor for cattle markets and are worst for Nyala, the most distant market. It is estimated that about 95 percent of the animals traded between western Sudan and other regions are trekked. The route from Nyala to Omdurman is about 1,400 kilometers, and the journey takes about 60 days during the rainy season (Babiker 1986), which partly explains the poor connection.

Markets appear to operate and to transmit price signals across regions. Even though such long-term regional price relationships exist and remain unaffected in periods of acute production shortfalls, poor market connections preclude markets from clearing at low levels because of high market-transaction costs. Transportation alone accounts for, on average, 10-15 percent of consumer price. A sample of market areas shows that the share of transportation ranges between one-fifth and nearly one-half of total marketing costs (Table 46). Ahmed and Rustagi (1987) also conclude, on the basis of their survey of African countries, that the share of transport varies from 35 to 50 percent of the total marketing cost. Moreover, they point out that the absolute transport cost in marketing is about twice as high in Africa as in Asia. This cost is largely associated with the poor road network, which is also evident from the comparison of transport shares in the sample of eastern and western market areas in the present study. The transport cost share is higher in western market areas, where the rural road network is less developed (Figure 10).

Other principal marketing cost components are storage and cost premiums associated with weight loss (Table 46). The two account for 20-40 percent of total

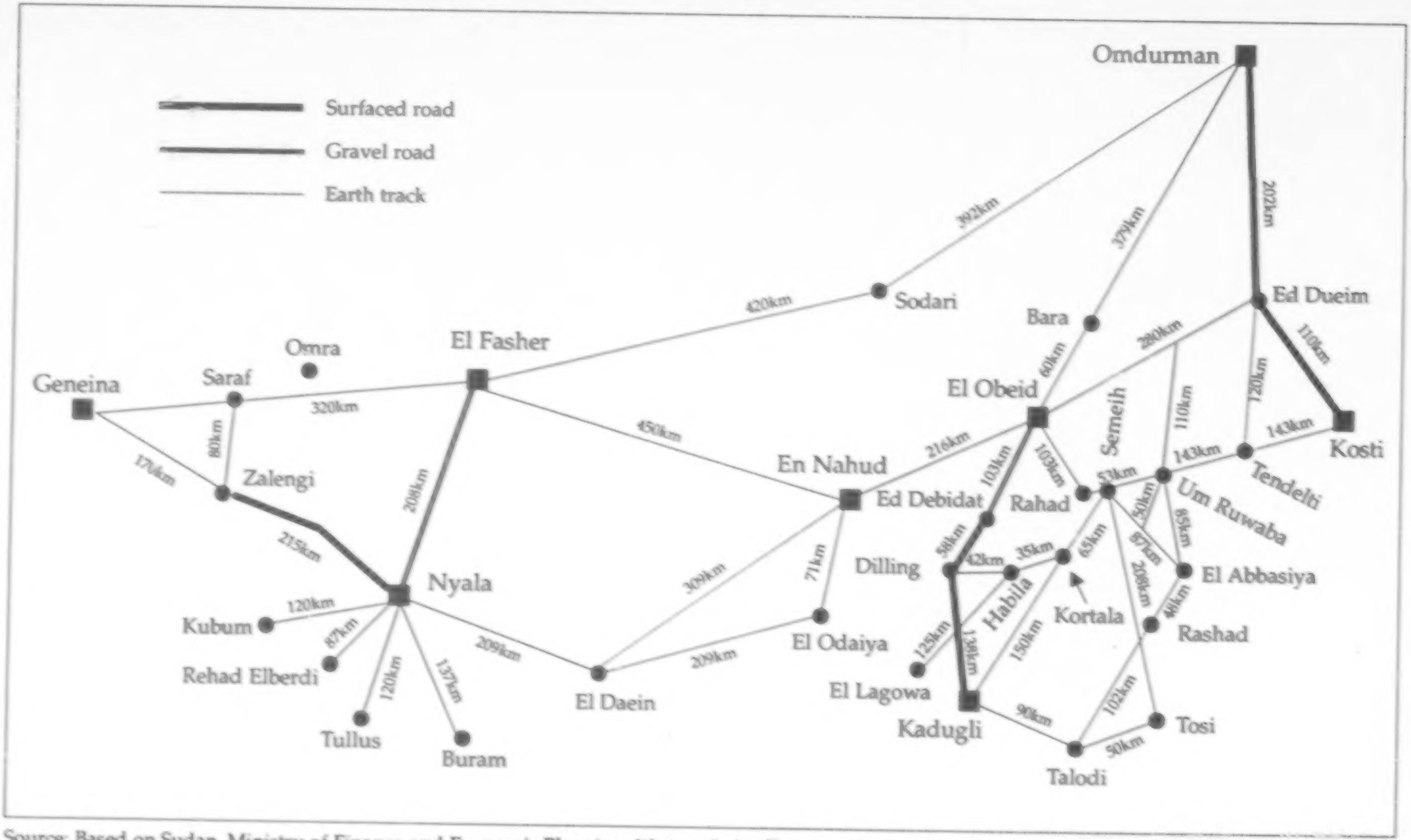
Table 46—Shares of marketing cost components for sorghum and millet, 1985-87

Commodity	Production Area	Consumption Area	Region	Year	Component Share				
					Transport	Handling	Taxes	Storage[a]	Weight Loss
							(percent)		
Sorghum (*feterita*)	El Doka/Gedaref	Gedaref	Eastern	1985/86	20.5	13.9	26.8	15.8	12.8
				1986/87	36.0	5.8	30.0	5.3	10.9
	Habila/Southern Kordofan	El Obeid	Kordofan	1985/86	39.0	10.1	6.8	21.7	18.7
				1986/87	44.5	6.5	8.4	23.4	11.9
	Nyala	Nyala	Darfur	1986/87	47.4	12.3	7.0	12.2	15.6
Millet	El Obeid	El Obeid	Kordofan	1985/86	38.8	8.8	7.9	12.1	29.2
	Nyala	Nyala	Darfur	1985/86	45.5	11.0	. . .	13.4	22.8

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Marketing Section, Khartoum, 1988.

[a] Storage includes the interest charge on working capital.

Figure 10—Road transportation network in western Sudan


Surfaced road
Gravel road
Earth track
Omdurman
202km
Ed Dueim
110km
Kosti
120km
143km
Tendelti
143km
Um Ruwaba
110km
280km
379km
392km
Sodari
420km
Bara
60km
El Obeid
Semeih
53km
50km
85km
El Abbasiya
87km
208km
48km
Rashad
102km
Tosi
50km
Talodi
90km
Kadugli
150km
138km
Habila
125km
El Lagowa
65km
Kortala
35km
42km
58km
Dilling
103km
Rahad
103km
Ed Debidat
216km
En Nahud
71km
El Odaiya
209km
309km
El Daein
450km
El Fasher
320km
Omra
Saraf
Geneina
80km
170km
Zalengi
215km
208km
Nyala
209km
120km
Kubum
87km
Rehad Elberdi
120km
Tullus
137km
Buram

Source: Based on Sudan, Ministry of Finance and Economic Planning, *Western Sudan Transport Study*, Main Report, vol. 1 (Khartoum: 1984).

marketing costs. The weight loss component of the marketing cost is greater for millet than for sorghum. Poor storage practices for millet contribute, for example, to a low price in the wet season, when other crops are at their height. In general, significant seasonal price variation due to the high cost of transfer across time characterizes cereal prices in Sudan.

Although information on the actual marketing costs during the food crisis is not available, it is clear that marketing costs were prohibitive in many instances where people were prepared to move to the food rather than expecting that the food would move to the people who still had the required purchasing power. A large share of the interregional migration is due to drought and food shortage, especially in western Sudan, where there is the combined effect of lack of food and lack of employment locally.

Short-Term Price Flexibility in Cereal-Livestock Terms of Trade

When drought hits an industrialized country with well-developed infrastructure, farm price increases of 10-20 percent, such as occurred in the 1988 drought in the United States, are considered large. Adjustments in stockholdings and trade permit a considerable degree of price stabilization under such conditions. Doubling or trebling of prices, as happened during the 1984 drought in Sudan, appears to be largely production-driven.

The key points quantitatively tested in the study are the degree to which production fluctuations—which were determined to be much influenced by the drought events above—result in price fluctuations, and the extent to which trade (including food aid) and stockholding are able to mitigate the fluctuations. The price-formation process is certainly complex and, in principle, requires a simultaneous look at the supply and demand sides and all the factors that determine each of these as well as due consideration of the expectations of agents on the supply and demand side of the market equations. With given data limitations, rather simple approaches are chosen here to explain price flexibility. The focus is on annual price fluctuations, and the demand side is not explicitly modeled. To the extent that short-term purchasing power is affected by production volume and price-level changes as well as price-ratio change (that is, cereal-livestock terms of trade), these are implicitly taken into account in the reduced-form model estimates chosen. First, an attempt is made to explain current-year cereal prices (in real terms) by total domestic supply and the previous year's ending stock levels:

$$\mathrm{PICER} = f(\mathrm{CERS}_t, \mathrm{STOCK}_{t-1}), \tag{7}$$

where

CERS_t = $\mathrm{CERP}_t + \mathrm{IMP}_t + \mathrm{FAID}_t - \mathrm{EXP}_t$,

PICER_t = index of the Sudan cereal price (deflated production-weighted mean of regional prices) in year t,

STOCK_{t-1} = level of cereal stocks per capita at end of year t−1 (or beginning-year stocks), in kilograms,

$CERP_t$ = cereal production per capita in year t, in kilograms,
IMP_t = imports per capita in year t,
$FAID_t$ = food aid per capita in year t,
EXP_t = net of exports per capita in year t, and
$CERS_t$ = total supply of cereals per capita from production ($CERP_t$), imports (IMP_t), net of exports (EXP_t), and food aid ($FAID_t$).

Second, the extent to which domestic production alone drives the price fluctuations is tested by excluding the trade and aid component from equation (7), that is, setting the index of cereal price as a function of current production per capita and previous-year cereal stocks per capita:

$$PICER = f(CERP_t, STOCK_{t-1}). \tag{8}$$

The same model estimation exercise is then repeated for the cereal-livestock terms of trade as

$$CLTOT_t = f(CERS_t, STOCK_{t-1}), \text{ and} \tag{9}$$

$$CLTOT_t = f(CERP_t, STOCK_{t-1}). \tag{10}$$

The models hypothesize that the real price index of cereals increases with a drop in domestic cereal production in the same year, but decreases when the last year's ending stocks or current year's opening stocks, respectively, are increased. Similarly, it is hypothesized that the terms of trade between cereals and livestock commodities are largely driven by the same set of hypotheses. The determinants of the cereal-livestock terms of trade may in fact be even more complex than the determinants of cereals' real price development because of the complex interactions between cereal markets and livestock markets, the differential effects of drought on cereal and livestock supply (distress sales of livestock drive prices down), and the adverse effects of increased cereal prices on the demand for livestock commodities by households. Again, a rather simple approach is taken here due to data limitations. The parameter estimates and estimation results are presented in Table 47.

With the help of the estimated parameters, the effects of a change in production of –10 percent and –30 percent, as well as a similar change in stocks, were derived for the cereal price and for the terms of trade. The results suggest that a drop of 30 percent in cereal production per capita raises cereal prices by 78 percent (equation [8] in Table 48). The order of magnitude is similar, resulting from a drop of 30 percent in production, for the cereal-livestock terms of trade: the terms of trade will increase by 57 percent (equation [10]). Holding other things constant, a decrease of 30 percent in cereal stocks would raise prices by 24 percent and the terms of trade by 18 percent. Similar models were run separately for Kordofan and Darfur, and these showed, relatively speaking, somewhat lower effects of local production fluctuations for local prices and local terms of trade, respectively. Given some domestic interregional trading, this outcome should be expected (Table 48).

Table 47—Regression equations for explanation of price flexibility and domestic terms-of-trade flexibility

Equation/ Dependent Variable	Explanatory Variables[a]			Constant	$\bar{R}^2$	F
	$CERP_t$	$CERS_t$	$STOCK_{t-1}$			
(7) PICER	. . .	−2.949 (−3.02)	−5.588 (−2.71)	725.29	0.436	5.0
(8) PICER	−2.775 (−5.31)	. . .	−4.355 (−3.46)	639.20	0.700	15.0
(9) CLTOT	. . .	−0.0251 (−5.68)	(−0.0456 (−4.90)	6.332	0.685	17.3
(10) CLTOT	−0.02037 (−9.81)	. . .	−0.03179 (−6.36)	5.069	0.887	50.9

[a] Parameters; t-values are in parentheses.

Definitions of variables:

$CERP_t$ = cereal production per capita, in kilograms;
$CERS_t$ = total supply of cereals per capita from production, imports, net of exports, and food aid;
$STOCK_{t-1}$ = level of cereal stocks per capita at end of year t−1, or beginning year stocks, in kilograms;
PICER = index of the Sudan cereal price (deflated production-weighted mean of regional prices); and
CLTOT = cereal-livestock terms of trade.

The main conclusion from this analysis is that, as a 1 percent drop in production at the national level tends to lead to about a 2.0-2.5 percent increase in prices in the short term, policies for production stabilization, stockholding, and facilitation of interregional trade are of critical importance. It may be most difficult to increase the short- and medium-run stability in cereal production given the dominance of the rainfed sector in this production. A fresh look at optimum storage levels, at

Table 48—Effects of production and stock changes for cereal prices and cereal-livestock terms of trade

Dependent Variable	Production Change		Stock Change	
	−10 Percent, Equations (8) and (10)	−30 Percent, Equations (8) and (10)	−10 Percent, Equations (8) and (10)	−30 Percent, Equations (8) and (10)
		(percent)		
Sudan cereal price	26.0	77.9	8.0	24.1
Sudan cereal-livestock terms of trade	19.1	57.3	5.9	17.6
Kordofan sorghum price	12.0	36.0	4.2	12.5
Kordofan sorghum-livestock terms of trade	12.6	37.7	3.6	10.7
Darfur millet price	14.7	44.2	2.8	8.5

Source: Computed from mean values of variables and parameters in Table 47.

investment in rural infrastructure for interregional trade, and at the option of stabilization through international trade in cereals requires consideration (see Pinckney 1989 on this issue). Research into the trade-offs between these options, which are not further explored here, could have a high payoff.

Price fluctuations are found to be driven predominantly by production fluctuations. The respective parameters estimated for CERS (total supply, including trade) change very little if production only is substituted (compare CERP and CERS parameters in Table 47). In fact, the explanatory power of the model decreases when total supply, rather than production only, is considered in the specification. Such a decrease may be explained by the timing of trade (aid) arrivals within the year, but this is only speculation.

6

IMPLICATIONS OF DROUGHT AND FAMINE FOR CONSUMPTION AND NUTRITION

Available evidence on Sudan suggests that households respond in varying degrees to income and price changes. The poor spend more than richer households on staple crops and are much more responsive to price and income changes. Hence, adjusting to drought-induced price and income changes is harder for the poorer households. An attempt is made here to pool available information on food and nutrient consumption in order to review and assess the impact of the 1984 drought, especially the aggregate and distributional effects of the drought on food and calorie demand and on nutritional-status indicators.

Food and Nutrient Consumption Practices

The studies reviewed here are based on a 1978-80 household consumption and expenditure survey (Sudan, Ministry of Finance and Economic Planning 1982). This chapter benefited from the work of Yisehac Yohannes (1989). The raw data from Darfur and Kordofan in the 1978-80 survey are utilized here for the first time to derive income and price response parameters. The information from these studies establishes the "normal" consumption situation preceding the 1984-85 famine.

The Sudanese spent about two-thirds of their average income on food during the 1978-80 period (Tables 49 and 50). There are, however, notable variations in

Table 49—Per capita expenditure and food share, by province and location, 1978-80

Province	Per Capita Expenditure	Food Share
	(SD£/month)	(percent)
Khartoum, urban	20.8	62.7
Khartoum, rural	12.5	73.7
Gezira	13.9	67.6
White Nile	9.3	68.0
Blue Nile	8.9	74.3
Nile	11.9	73.3

Sources: Based on Angus Deaton and Anne Case, *Income Distribution, Poverty, Expenditure Patterns and Price Elasticities in the Sudan*, Report to the USAID mission to Sudan, 1985; and data files from the Ministry of Finance and Economic Planning, Khartoum.

Table 50—Per capita expenditure and income, family size, food share, and calorie consumption, by province and income quartile, 1978-80

Province/ Income Quartile	Per Capita Expenditure	Per Capita Income	Family Size	Food Share	Calorie Consumption
	(SD£/year)			(percent)	(kilocalories/ person/day)
Northern Kordofan	103.5	124.3	6.7	61.5	2,566
Northern Darfur	128.9	140.9	5.5	52.8	2,427
Northern Kordofan					
Quartile 1	53.27	67.88	8.5	68.2	1,667
Quartile 2	83.74	98.25	6.1	60.7	2,236
Quartile 3	107.62	132.62	6.4	62.8	2,869
Quartile 4	169.41	198.27	5.7	54.5	3,482
Northern Darfur					
Quartile 1	51.37	84.34	6.2	59.5	1,724
Quartile 2	89.25	64.96	5.8	59.2	2,297
Quartile 3	135.74	104.37	5.4	47.5	2,417
Quartile 4	237.92	309.15	5.4	45.0	3,247

Source: Based on data tape from the Ministry of Finance and Economic Planning, Department of Statistics, Khartoum.

the size of these shares among regions. A comparison of urban and rural Khartoum shows that the rural population allocated more of its income to food. The shares across provinces appear to follow the expected inverse relation between income level and food share, except for the western provinces of Northern Kordofan and Northern Darfur, and White Nile Province in Central Region. Shares were greater in Blue Nile and Nile provinces relative to Gezira and urban Khartoum, reflecting partly the low income level in the Nile provinces.

The expected inverse relationships are more regular among income groups within the same regions. In Northern Kordofan, for example, the poorest households (those in the bottom 25 percent of income distribution) allocated, on average, 14 percent more of their income to food than did the upper 25 percent (Table 50). The same pattern of behavior in the food share is observed in the Northern Darfur sample. In fact, share elasticity estimates for these provinces range between −0.44 (Northern Kordofan) and −0.45 (Northern Darfur); that is, food share drops by 0.5 percent for a 1.0 percent increase in per capita expenditure. Income allocated to food decreases at the margin with an increase in income level.

The average person in the west, particularly in Northern Kordofan and Northern Darfur, spent no less than 30 percent of the food budget on cereals (Table 51). Millet was the most prominent item in the food budget. Sorghum, the dominant staple in central and eastern Sudan, was a distant second, averaging about 10 percent in the west. Other important food groups were sugar, vegetables, and meats. A relatively high share of sugar in the food budget is characteristic of a Sudanese diet.

The allocation of food budgets across these food components appears to vary with income level. The case of Northern Darfur in 1978-80 is presented in Table 52. The food shares for cereals decline with income—from 45 percent in the lowest

Table 51—Share of food components in total food budget, by province, 1978-80

Food	Northern Kordofan	Northern Darfur	Southern Darfur
		(percent)	
Cereals[a]	35.23	32.60	30.17
Sorghum	12.42	5.50	5.57
Millet	21.83	26.08	23.47
Cereal products[b]	0.58	0.68	1.41
Vegetables	7.74	7.61	8.21
Milk	2.81	2.80	3.73
Meat	9.22	15.32	14.25
Sugar	16.84	14.40	17.57
Beverages[c]	10.74	3.63	5.07
Oils and fats	9.62	7.46	8.70
Condiments	3.70	3.63	3.27
Other	3.52	11.87	7.62

Source: Based on Yisehac Yohannes, "Food Consumption Patterns in Western Sudan, 1978-80," Famine and Food Policy Discussion Paper 1 (International Food Policy Research Institute, Washington, D.C., 1990, mimeographed).

[a] Cereals are sorghum, millet, maize, wheat, barley, rice, and others.

[b] Cereal products are wheat flour, *kisra*, and bread.

[c] Beverages are nonalcoholic drinks, tea, and coffee.

Table 52—Variation in food budget shares in Northern Darfur, by expenditure group, 1978-80

Food	Expenditure Group[a]		
	Low	Medium	High
		(percent)	
Cereals	45.50	30.75	23.42
Sorghum	16.75	2.44	0.63
Millet	28.52	27.52	20.63
Vegetables	6.33	7.91	8.26
Milk	2.28	2.81	3.31
Meat	13.35	16.13	15.61
Sugar	9.03	15.41	17.65
Beverages	2.31	3.58	5.03
Oils and fats	5.39	8.24	7.90
Condiments	3.92	4.48	5.49
Other	11.89	10.69	13.33

Source: Based on data tape from the Ministry of Finance and Economic Planning, Department of Statistics, Khartoum.

[a] Low refers to the bottom 25 percent of expenditure distribution, medium to the 50th to 75th percentile, and high to the top 25 percent. The remaining 25 percent were not reported.

income bracket to 23 percent in the highest. The poor in this region thus tend to concentrate on cereals. The shares of other food groups, notably vegetables, meats, and sugar, appear to increase with income.

The behavior of these shares across income levels also establishes that these food groups are income-sensitive. Measuring such responses and drawing inferences are, however, tenuous exercises given the weak data base. Notwithstanding such qualifications, this study pooled selected demand elasticity estimates from other studies based on the same 1978-80 survey data in other provinces of Sudan (Table 53). The studies are not quite comparable in commodity coverage, location, and demand forms; however, they provide some noticeable patterns. First, the food groups are responsive to changes in relative prices and income level. Second, price and expenditure elasticities decline as average income level rises and the discretionary component of household budgets increases with income. The large drop of the expenditure elasticity in urban Khartoum may reflect the increasing diversity of foods and declining share of cereals in the food budget. The elasticities in urban Khartoum present lower bounds for the country. Cereals, for example, have an attribute of a normal good (that is, positive income elasticity), and higher coefficients are expected in other regions. Third, cereal products, sugar, and tea are more income-responsive than cereals. This is consistent with observed food share and income relation in Northern Darfur.

The nutritional dimension of these food groups contributes information essential for understanding variation in nutritional status among the population. The last

Table 53—Selected own-price and expenditure elasticities, 1978-80

Study	Demand Functional Form	Area	Commodity	Expenditure Group[a]	Elasticity	
					Own Price	Income/ Expenditure[b]
Pinstrup-Andersen et al., 1983	Linear expenditure system	Urban Khartoum	Cereals	Strata 1-2	-0.39	0.38
				Strata 3-4	-0.37	0.38
				Stratum 5	-0.29	0.18
			Bread	Strata 1-2	-0.81	0.79
				Strata 3-4	-0.68	0.71
				Stratum 5	-0.22	0.14
			Sugar	Strata 1-2	-1.00	0.99
				Strata 3-4	-0.92	0.97
				Stratum 5	-0.34	0.02
Deaton and Case, 1985	Log linear	Sudan[c]	Sorghum	All	-0.69	0.13
			Sugar	All	-0.64	0.57
			Tea	All	-0.50	0.50

Sources: Based on Pinstrup-Andersen et al., "Impact of Changes in Income and Food Prices on Food Consumption by Low-Income Households in Urban Khartoum with Emphasis on the Effect of Changes in Wheat-Bread Points" (International Food Policy Research Institute, Washington, D.C., 1983, mimeographed); and Angus Deaton and Anne Case, *Income Distribution, Poverty, Expenditure Patterns and Price Elasticities in the Sudan*, Report to the USAID mission to Sudan, 1985.

[a] Stratum 1 is 12.5 percent of the survey households with the lowest total expenditure per capita; strata 2, 3, and 4 are each the next highest 12.5 percent; and stratum 5 is the highest 50 percent.

[b] Pinstrup-Andersen et al. reported income elasticities, while Deaton and Case estimated expenditure elasticities.

[c] Excluding the western regions of Darfur and Kordofan.

column in Table 50 shows that the average daily energy consumption exceeds 2,400 calories in Northern Kordofan and Northern Darfur. If one assumes a threshold of 2,100 calories, availability of calories was adequate on average in these provinces in the 1978-80 period.

The cereal crops as a group contributed over 65 percent of the calorie level (Table 54). Millet, the predominant staple in the west, was the main source, contributing about half.

Despite average adequacy, however, calorie consumption was uneven across expenditure groups (see Table 50 for the west and Table 55 for urban Khartoum). Households in the lowest expenditure distribution were prone to calorie deficiency. Large variations, however, were not found only in households with low income. A previous study on urban Khartoum (Pinstrup-Andersen et al. 1983) identified the key attributes of calorie-deficient households as related to large family size, low allocation of income to food, and choice of diet (Table 55). Their findings show that the poor had large families and (unlike the calorie-deficient) spent more on food and placed a high priority on cheap calories. Calorie deficiency is, therefore, not strictly income-determined. If, however, one speculates that it is the poor who are likely to face low degrees of freedom in their income uses or pay high search costs to identify low-cost diets, or both, the calorie-deficient may then be found to be concentrated among the poor. Further inquiry is made into this with a directly specified calorie-consumption function of the form

$$\ln PCDCL = \beta_0 + \beta_1 \ln PCEXP + \beta_2 \ln PCEXP^2 + \beta_3 HHSZ + \beta_4 PRCE, \qquad (11)$$

where

$\ln PCDCL$ = natural log of per capita daily calories,
$\ln PCEXP$ = natural log of annual per capita expenditure,
$\ln PCEXP^2$ = square term of $\ln PCEXP$,
$HHSZ$ = household size,

Table 54—Share of food components in total calories, by province, 1978-80

Food	Northern Kordofan	Northern Darfur	Southern Darfur
Cereals	66.20	71.56	58.23
Sorghum	27.63	11.64	12.90
Millet	37.62	59.22	44.40
Cereal products	0.34	0.18	0.32
Vegetables	3.47	3.54	3.02
Milk	2.01	1.71	4.10
Meat	2.11	3.48	4.65
Sugar	7.42	4.41	8.36
Oils and fats	16.40	12.57	19.22
Other	2.05	2.55	2.10

Source: Based on data tape from the Ministry of Finance and Economic Planning, Department of Statistics, Khartoum.

Table 55—Variation in income, expenditure, calorie consumption, family size, food share, and calorie price, urban Khartoum, 1978-80

Strata	Population Share	Total Income Share	Calorie Sufficiency	Family Size	Per Capita Income	Per Capita Expenditure	Food Share	Calorie Price
	(percent)		(calories)	(persons)	(SD£/month)		(percent)	(SD£)
Calorie[a]								
Stratum 1	19.81	12.83	−960.84	9.3	15.11	12.06	41.02	0.114
Stratum 2	18.75	14.75	−240.05	8.7	18.17	16.62	41.62	0.106
Stratum 3	17.84	16.69	+233.24	7.8	21.82	17.49	47.85	0.107
Stratum 4	44.20	56.33	+1,698.03	5.4	29.72	37.10	49.42	0.110
All	100.00	100.00	+566.77	6.8	23.32	20.50	47.03	0.110
Expenditure								
Stratum 1	17.59	6.42	−563.36	9.6	8.52	7.00	64.84	0.087
Stratum 2	15.04	7.60	−18.60	8.2	11.79	10.08	63.49	0.092
Stratum 3	13.80	8.61	+228.33	7.5	14.55	12.53	60.86	0.098
Stratum 4	12.90	9.94	+528.29	7.0	17.97	15.27	59.04	0.103
Stratum 5	40.67	67.43	+1,374.39	5.5	38.66	34.81	40.37	0.132

Source: Based on Pinstrup-Andersen et al., "Impact of Changes in Income and Food Prices on Food Consumption by Low-Income Households in Urban Khartoum with Emphasis on the Effect of Changes in Wheat-Bread Points" (International Food Policy Research Institute, Washington, D.C., 1983, mimeographed), Tables 1-11.

[a] Stratum 1 consumes below 80 percent of requirements; stratum 2, 80-100 percent; stratum 3, 100-120 percent; and stratum 4, above 120 percent.

PRCE = price of millet for Northern and Southern Darfur, and price of sorghum for Northern Kordofan, and

β_0, β_1, β_2, β_3, and β_4 are parameters to be estimated.

Each equation is related to per capita expenditure, household size, and price of main cereal crop. The equations were estimated using the 1978-80 data from the western provinces. The parameter estimates and associated t-statistics are reported in Table 56. Both the linear and quadratic terms of income are statistically significant. The signs suggest that income has a positive but diminishing effect on calorie consumption. Household-size signs are negative but significant only in the Darfur sample. The signs are consistent with the observation that households with comparable incomes but larger families consume fewer calories on average. The price of millet has a significant inverse effect on calorie consumption, reflecting its importance in the diets of the western provinces.

Elasticity estimates evaluated at sample means are given in Table 57. Calorie income elasticities range between 0.36 and 0.58. The elasticities imply that a 1.0 percent increase in per capita expenditure translates on average into an increase in calorie consumption between 0.36 and 0.58 percent. An increase in the price of millet has the opposite effect. A 1.0 percent increase in the price results on average in a drop in calories of 0.29-0.36 percent. If one accepts the inverse relation hypotheses (for example, Pinstrup-Andersen and Caicedo 1978; Timmer and Alderman 1979), these responses would be higher among poor households.

Table 56—Parameter estimates for calorie demand, by province

Province	Independent Variables[a]				Constant	$\bar{R}^2$	F
	lnPCEXP	lnPCEXP^2	HHSZ	PRCE			
Northern Darfur	1.16	−0.08	−0.05	−3.84	4.79	0.70	53.85
	(3.12)	(−2.05)	(−5.57)	(−3.93)	(5.54)		
Southern Darfur	1.03	−0.05	−0.03	−2.27	4.45	0.65	97.53
	(4.07)	(−1.91)	(−4.97)	(−3.12)	(7.49)		
Northern Kordofan	1.44	−0.09	−0.01	−2.97	3.52	0.56	43.00
	(2.61)	(−1.49)	(−1.18)	(−2.23)	(2.79)		

Source: Based on data tape from the Ministry of Finance and Economic Planning, Department of Statistics, Khartoum.

Note: The figures in parentheses are t-statistics.

[a] Definitions of variables:

lnPCEXP = natural log of annual per capita expenditure;
lnPCEXP^2 = square term of lnPCEXP;
HHSZ = household size;
PRCE = price of millet for Northern and Southern Darfur, and price of sorghum for Northern Kordofan.

Table 57—Elasticity estimates for calorie consumption, by province

Province	Expenditure Elasticity	Size Elasticity	Price Elasticity
Northern Darfur	0.36	−0.29	−0.36
Southern Darfur	0.55	−0.21	−0.29
Northern Kordofan	0.58	[a]	−0.29

Source: Yisehac Yohannes, "Food Consumption Patterns in Western Sudan, 1978-80," Famine and Food Policy Discussion Paper 1 (International Food Policy Research Institute, Washington, D.C., 1990, mimeographed).

[a] Estimated parameter is not significant.

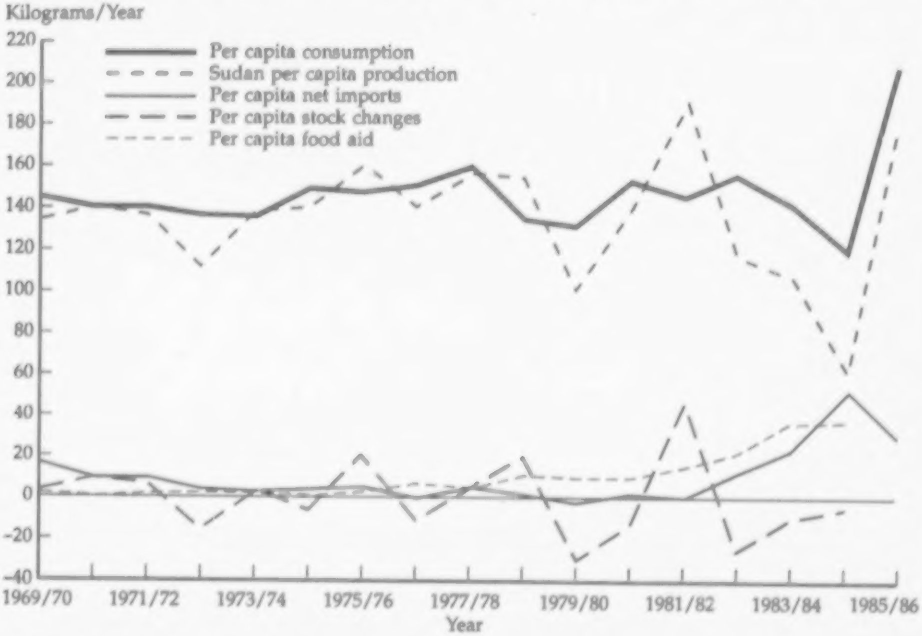
The observed empirical food and calorie demand behavior are largely comparable with studies in other low-income countries (Waterfield 1985; Pinstrup-Andersen 1985; Alderman 1986; Svedberg 1987). Low-income households spend a large share of their income on food. Income elasticities for food decline with income level. Low-income households are also sensitive to price changes. Food price changes cause more consumption adjustment among the poor because of their large food share and income elasticity. In other words, the burden of adjustment falls heavily on the low-income households in a period of food scarcity. Calorie elasticities also appear to fall with rising income. Svedberg's (1987) review of literature on microlevel studies on Africa highlights these relationships. Moreover, it stresses that calorie deficiency is a more serious problem and tends to be more unstable in villages located in unimodal and semi-arid zones. Infants and small children are the most at risk when it comes to malnutrition or undernutrition.

Decline in Food Availability

The absence of time-series data poses an information constraint to studying disaggregated Sudanese food consumption patterns over time. The best that may be done is to use an aggregate measure of food availability from food-balance-sheet estimates. Available food consumption estimates are derived from the aggregation of net domestic production available less net trade and net stock changes. These estimates in general set the upper bounds to actual consumption levels. FAO-based estimates are used here to examine the behavior of aggregate food consumption over time.

Cereal-food availability in Sudan is much determined by domestic staple food production (Figure 11). Domestic food production contributes on average 90 percent of total cereal consumption. There are, of course, marked variations among the

Figure 11—Per capita food consumption in Sudan, 1969/70–1985/86



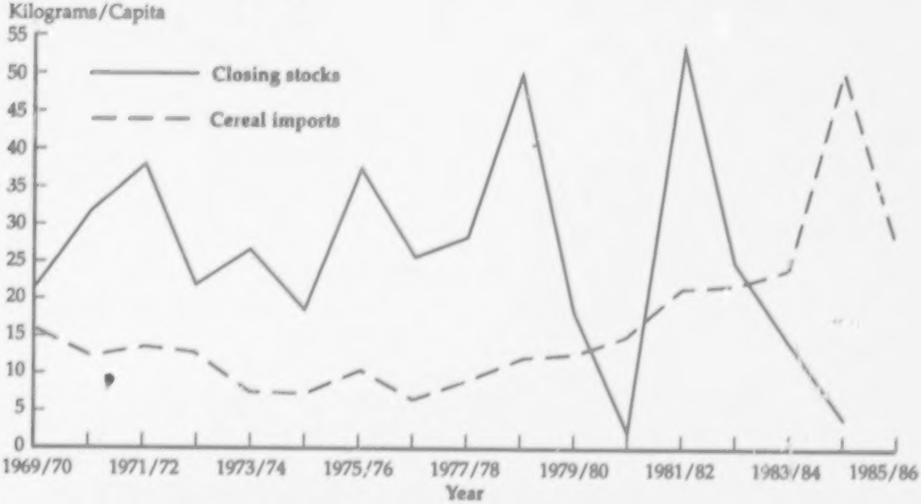
Sources: Compiled and computed from Sudan, Ministry of Agriculture and Natural Resources, *Yearbook of Agricultural Statistics* (Khartoum: MANR, 1977 and 1984); *Current Agricultural Statistics*, vol. 1, no. 4 (Khartoum: MANR, 1984); *Agricultural Situation and Outlook, Annual Report, 1984/1985* (Khartoum: MANR, 1985); and *Agricultural Situation and Outlook, Annual Report, 1986/87* (Khartoum: MANR, 1987); Food and Agriculture Organization of the United Nations, Office for Special Relief Operations, *Democratic Republic of Sudan, Report of the FAO/WFP Multidonor Mission, Assessment of the Food and Agricultural Situation*, OSRO Report 02/85/E (Rome: FAO, 1985); *Agricultural Trade Yearbook* (Rome: FAO, various issues); *Food Aid in Figures* (Rome: FAO, various issues); and "Food Supply Utilization Data Tape for Sudan," FAO, Rome, 1984.

individual cereal crops. Millet, the preferred crop in the west, is consumed solely from domestic production. The same applies to sorghum, which is largely consumed in the central, eastern, and southern regions. In fact, the nation registered a surplus production of sorghum in the late 1970s and 1980s and managed to export or build reserve stocks or both. The relative contribution of domestic production to wheat consumption is much lower, averaging 39 percent in the 1980s. Yet wheat is central to the policy debate in Sudan because of its relative preference among the urban population in greater Khartoum and other urban areas.

Relative contributions of imports and domestic stocks play a minor role in annual millet and sorghum availability. Years of large production shortfalls like 1982-84 are exceptions. Production as a share of consumption fell to a low 75 percent in 1984. To cope with the shortages, the government adopted a mix of measures, such as banning export of sorghum, drawing down reserve stocks, and appealing for outside support, which came largely in the form of grants and concessionary imports. In fact, the dwindling domestic production of wheat in the 1980s was made up largely from increased concessionary imports, which averaged 88 percent in the period between 1982 and 1986. These components are likely to remain important sources for the government to fall back on in periods of poor harvests.

Moreover, while Sudan traditionally faces a problem of extreme fluctuations in stocks, there also seem to have been increases in these fluctuations in the 1980s (Figure 12). (It should be noted that official stock figures are not all comprehen-

Figure 12—Per capita stocks available and per capita cereal imports in Sudan, 1969/70–1985/86



Sources: Compiled and computed from Food and Agriculture Organization of the United Nations, *Trade Yearbook* (Rome: various issues); FAO, Office for Special Relief Operations, *Democratic Republic of Sudan, Report of the FAO/WFP Multidonor Mission, Assessment of the Food and Agricultural Situation*, OSRO Report 02/85/E (Rome: FAO, 1985); and "Food Supply Utilization Data Tape for Sudan," FAO, Rome, 1985.

sive.) In view of the increased production fluctuations, the policies for stockholding and trading have certainly become more complex, and management of trade and stocks has become a much larger issue in terms of volume, fiscal costs, foreign exchange implications, and national human welfare.

Food availability per capita declined notably between 1970 and 1986. The annual growth rate was a significant −1.4 percent, largely reflecting the low growth in production relative to population. The trend diminishes (−0.7 percent) when the effect of the 1984 drought is controlled for, which evidences the strong adversity of the drought-production effect on cereal consumption. Average per capita cereal consumption dropped from a high of 100 kilograms in 1976 to 78 kilograms in 1983 and to 51 kilograms in 1984. The years 1985 and 1986 witnessed marked recovery but not to the magnitude of the prefamine level.

Incidence of the 1984-85 Famine

Aggregate declines in per capita consumption may not be accompanied by proportional drops across socioeconomic groups. In fact, the evidence shown above suggests that demand responses are varied. Of course, one needs a disaggregated demand matrix to trace the effects of, say, the 1984 drought on food and nutrient consumption across income groups. Such estimates should also preferably be reflective of behavior during the adjustment period. No such empirical estimates exist to assess drought-induced hunger effects.

Nevertheless, the demand estimates based on 1978-80 data could be used to approximate the hunger effects. Suppose the hunger indicator is calorie consumption below a certain level. The effect of change in rainfall on calorie consumption can be approximated through a recursive relationship of rainfall to production to calorie/price and calorie/income.[6] For example, the effect of a 10 percent change in rainfall in western Sudan translates into an average 3.5 percent reduction in calorie consumption. Note that these values are on the lower bounds, since the calorie elasticities are lower in the long run than in the short run.

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[6] These relations can be depicted for

$$\begin{aligned} \text{price effect} &= \eta_{CRP} = \eta_{CP} \cdot \eta_{PQ} \cdot \eta_{QR}, \\ \text{income effect} &= \eta_{CRI} = \eta_{CY} \cdot \eta_{YQ} \cdot \eta_{QR}, \text{ and} \\ \text{total effect} &= \eta_{CR} = \eta_{CRP} + \eta_{CRI}, \end{aligned}$$

where

η_{CR} = calorie elasticity with respect to rainfall index (P = price effect, I = income effect),

η_{CP} = calorie elasticity with respect to price,

η_{PQ} = price elasticity with respect to production,

η_{QR} = output elasticity with respect to rainfall index,

η_{CY} = calorie elasticity with respect to income, and

η_{YQ} = income response with respect to cereal production (it is assumed that cereal-based income accounts directly and indirectly for nearly 80 percent of rural household income).

Nutrition-based sample surveys were also carried out widely in western Sudan in 1985 and 1986. These surveys were based on anthropometric measures of change in weight relative to height of children under five years old. The measures were compared with standard reference groups in order to identify groups that would qualify for food distribution and supplementary feedings and to monitor the nutritional effects of severe food shortages during the droughts. Examination of these results provides an additional dimension of the extent to which the droughts affected the population.

The OXFAM-UNICEF nutritional surveillance project, which was implemented in collaboration with the regional governments of Kordofan and Darfur, presents a more complete and consistent picture of the situation in 1985 and early 1986 (Table 58). By early 1985, about 13 percent of the children in Northern Kordofan were malnourished, that is, under 80 percent of the WHO/NCHS standard. The proportion peaked at 25 percent in mid-1985 and then dropped to 11 percent during the 1985 harvest. The situation markedly improved by early 1986 when it reached 7.5 percent. Within Northern Kordofan, the children in Bara and Sodari and north of Um Ruwaba district were relatively more malnourished, that is, those in the northern arid region were severely at risk.

The link between price change and child malnutrition is depicted in Figure 13. The dramatic deterioration of purchasing power caused by unfavorable changes in terms of trade was translated into increased incidence of severe child malnutrition in Kordofan. The market strongly affected the poor, and children in particular.

The price effects of the 1984 drought were also transmitted to the urban population despite numerous government interventions with the subsidy and rationing systems. The urban poor spent 65 percent of their total budget on food. The bottom 20 percent, in terms of per capita expenditure, tend to be deficient in food energy even in normal years such as 1979, when a food-expenditure survey was made in urban Khartoum (Pinstrup-Andersen et al. 1983). The price elasticity of cereals and bread among these poor sections of the urban population ranges from about -0.7 to -0.8, that is, a 1.0 percent increase in price reduces consumption by 0.7 percent. Households in upper-income groups respond much less to price changes for staple foods. Their price elasticity for cereals was estimated at -0.29 and for bread at -0.22 (Table 53).

A drastic decline in food availability in rural areas and the related movements of people into urban areas have probably led to a major decline in real wages and employment for those who were already urban residents and dependent on employment in service jobs at the lowest income brackets. This is to say that the food production crisis has probably been transmitted into urban areas not only via its widespread price effects but also through its effects on urban labor markets. Certainly the massive influx of drought victims into the urban and peri-urban areas should have contributed to increased inequality of income in the 1980s.

Nutritional Situation after the 1984-85 Famine

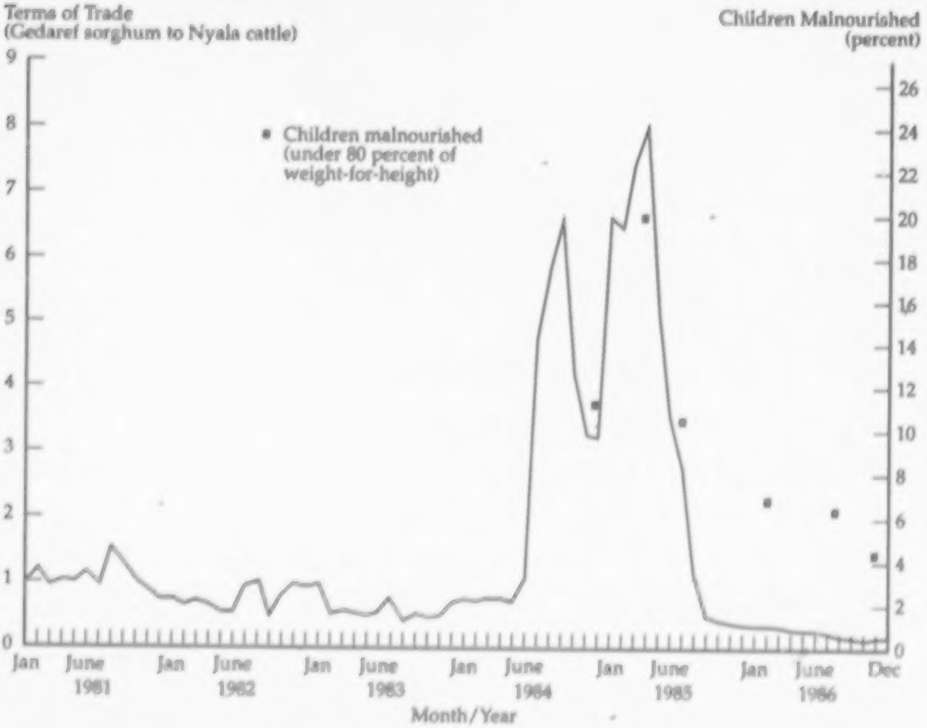
The 1984-85 famine ended with the coming of a good crop year in 1985. Improved food-aid distribution partly alleviated the situation in western Sudan in the second half of 1985. What was the nutritional situation after the famine?

Table 58—Proportion of children below 80 percent and 70 percent of standard weight-for-height among sedentary population in Kordofan, 1985/86

Site	February/March 1985			May/June 1985			September/October 1985			March/April 1986		
	Sample Mean	Under 80 Percent	Under 70 Percent	Sample Mean	Under 80 Percent	Under 70 Percent	Sample Mean	Under 80 Percent	Under 70 Percent	Sample Mean	Under 80 Percent	Under 70 Percent
	(percent of children)											
Kordofan Region	89.0	11.9	0.8	86.6	19.7	2.6	89.2	10.4	0.9	90.7	6.9	0.7
Northern Kordofan Province	88.7	13.1	1.1	84.7	25.2	3.4	89.1	11.0	1.2	90.0	7.5	0.7
Southern Kordofan Province	89.3	10.2	0.4	89.4	11.5	1.3	89.5	9.5	0.5	91.4	6.0	0.7

Sources: OXFAM-UNICEF and Kordofan Regional Government, "A Report on the Nutritional Status of 1,888 Children in Kordofan, February/March 1985"; "The Nutritional Status of Children in Kordofan, May/June 1985"; "The Nutritional Status of 4,575 Children in Kordofan Region, September/October, 1985"; and "The Nutritional Status of 3,183 Children in Kordofan Region, March 1986" (mimeographed)..

Figure 13— Seasonal cereal-livestock terms of trade and child malnutrition, January 1981–December 1986



Sources: Computed from price series data compiled from Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970–1984* (Khartoum: MANR, 1985); *Agricultural Situation and Outlook, Annual Report, 1984/85* (Khartoum: MANR, 1985); *Agricultural Situation and Outlook, Annual Report, 1986/87* (Khartoum: MANR, 1987); Sudan, Ministry of Health and Social Welfare, Sudan Emergency and Recovery Information and Surveillance System (SERISS) data tapes, 1986 and 1987.

Sudan's 1986-87 nutritional status survey (the largest in Sub-Saharan Africa) provides a data base to pursue this question.[7] It is used here to describe the pattern and causes of child malnutrition.

The October/November 1986 survey results show that 35 percent of children under five years of age were stunted (height-for-age), 42 percent were underweight (weight-for-age), and 16 percent were wasted (weight-for-height), using less than −2 standard deviations of Z-scores for respective measures (Table 59 and Figure 14). The seasonality effect was much stronger for the short-term indicator (weight-for-height), where the after-harvest, food-rich situation improved the nutritional situation in January/March 1987.

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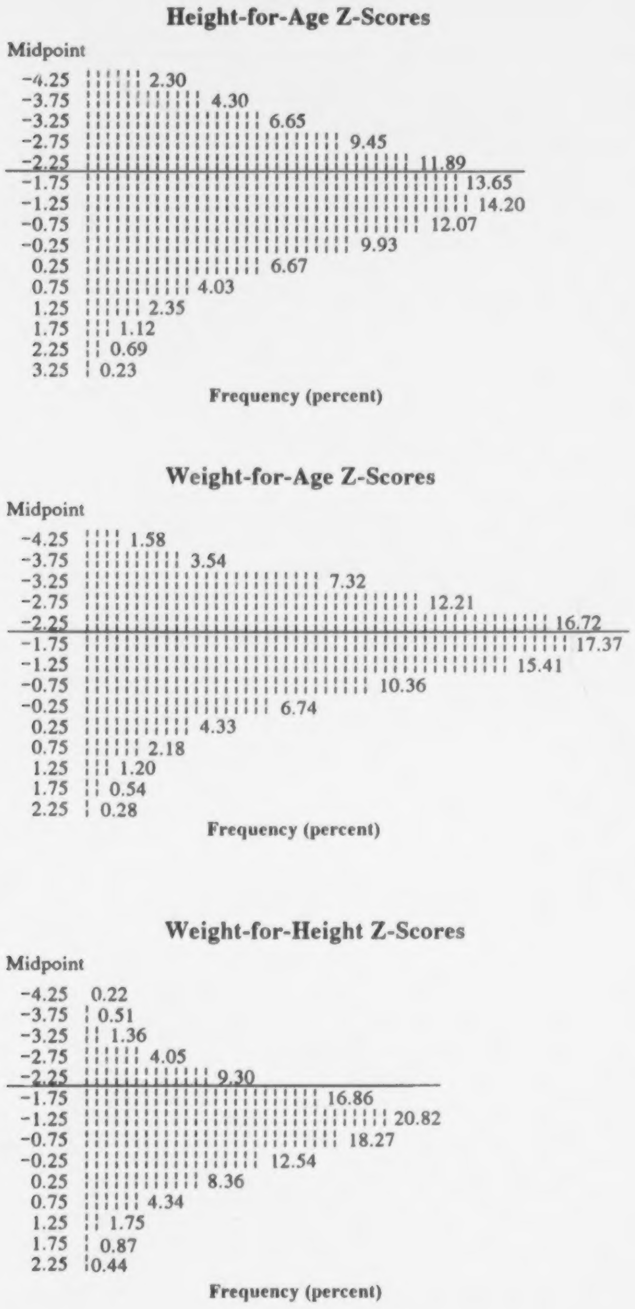
[7] For more details on survey design and sampling procedures, see Sudan, Ministry of Health and Social Welfare 1986a.

Table 59—Proportion of children under five years of age with below −2 Z-scores for standard indicators, 1986/87

Province/ Location	Weight-for-Height			Weight-for-Age			Height-for-Age		
	October-November 1986	January-March 1987	May-July 1987	October-November 1986	January-March 1987	May-July 1987	October-November 1986	January-March 1987	May-July 1987
					(percent of children)				
Province									
Khartoum	0.21	0.11	0.10	0.35	0.29	0.27	0.21	0.23	0.21
Northern	0.15	0.06	0.17	0.29	0.18	0.34	0.17	0.18	0.25
Nile	0.18	0.07	0.14	0.39	0.30	0.34	0.29	0.30	0.25
Red Sea	0.27	0.06	0.09	0.63	0.43	0.36	0.53	0.54	0.39
Kassala	0.14	0.07	0.10	0.43	0.36	0.45	0.37	0.40	0.45
Blue Nile	0.14	0.07	0.14	0.42	0.40	0.47	0.34	0.39	0.39
Gezira	0.09	0.02	0.09	0.46	0.33	0.38	0.47	0.41	0.32
White Nile	0.13	0.07	0.14	0.43	0.34	0.42	0.38	0.36	0.35
Northern Kordofan	0.11	0.08	0.13	0.36	0.34	0.40	0.34	0.35	0.33
Southern Kordofan	0.09	0.08	0.15	0.39	0.32	0.36	0.36	0.33	0.27
Northern Darfur	0.21	0.11	0.14	0.47	0.33	0.34	0.37	0.29	0.25
Southern Darfur	0.20	0.14	0.12	0.43	0.34	0.35	0.33	0.26	0.30
Location									
Urban	0.14	0.06	0.09	0.31	0.22	0.26	0.22	0.22	0.22
Rural	0.16	0.09	0.13	0.45	0.36	0.40	0.38	0.37	0.34
Nomad	0.17	0.06	0.14	0.52	0.35	0.45	0.47	0.39	0.34
Sudan	0.16	0.08	0.12	0.42	0.33	0.37	0.35	0.33	0.31

Source: Computed from Sudan, Ministry of Health and Social Welfare, Nutrition Division, *Sudan Emergency and Recovery Information and Surveillance System (SERISS)*, Operational Manual (Khartoum: MANR, 1986).

Figure 14—Relative distribution of sample children, by type and level of anthropometric status indicator, Sudan, 1986



The prevalence of malnutrition was higher in rural areas, particularly among the nomads, but the levels were also high for urban areas. Large regional variations were also observed. The worst areas were Red Sea, Kassala, and Gezira Provinces. Clearly, the country had a persistent food-security problem with significant variations across locations (urban/rural), provinces, and seasons (see also Maxwell 1989). Urban areas themselves are not free of sizable seasonality effects (see weight-for-height, Table 59).

Causes of Malnutrition

The large regional coverage of the Sudan Emergency and Recovery Information and Surveillance System (SERISS) surveys of children (Sudan, Ministry of Health and Social Welfare 1986b and 1987) and the presence of community-related variables allow some unique analysis. Community-level data are available only for the round 3 (January/March 1987) and round 4 (May/July 1987) surveys. These two rounds are used in this study, pooling about 30,000 children for a two-stage regression analysis. The model explaining the nutritional status of preschool children (weight-for-age) comprises the following exogenous variables:

- child demographics (SEX, KIDAGE, KIDAGESQ);
- household demographics (SIZE, SIZESQ, TOTKIDS);
- parents' sociodemographics, including human capital (MOTHAGE, MAOCCUP, MOTHLT, FATHLT);
- household food-consumption level (LGRPRE);
- meal frequency (MEALLT3);
- child health, short term (DIARPRE); and
- community health environment (INFECT, HLTHSERV).

To account for endogeneity of food consumption (LGRPRE) and short-term health status (DIARPRE), both of these critical variables are instrumentalized. Variables related to price, agricultural technology, and community income enter the instrumentalization of the consumption variable. Particular attention is given to including availability of piped water in villages and prevalence of irrigated agriculture as variables for diarrhea prediction.

The main hypotheses underlying the model specification are that

- improved household (parents) human capital improves nutrition (MOTHLT, FATHLT);
- higher levels of food consumption per capita and higher meal frequency in the household improve nutrition (LGRPRE, MEALLT3);
- children who currently have diarrhea (DIARPRE) are worse off, especially in the short term, but also in the long term to the extent that current diarrhea is a symptom of a persistent problem;
- a poor health environment and limited access to health services contribute to a worse nutritional situation (INFECT, HLTHSERV); and
- an improved piped-water supply improves nutrition via reduced diarrhea (PIPEWTR).

Regression estimates for nutritional status indicators are used to test these hypotheses, conditional on a set of child and household demographic characteristics. In addition, there are tests for seasonality (ROUND3) and effects of residence in predominantly mechanized (MECHY) or irrigated (IRRGY) areas, compared with traditional rainfed agriculture entered through the instrumentalization of the health and food consumption variables (see list of variables in Table 60).

The results largely substantiate these hypotheses and give additional interesting insights (Tables 61 and 62). The following are the highlights of the findings:

1. Parents' education, especially mother's education in the long term, has a positive impact on child nutrition. In fact, mother's literacy increases child nutrition, holding other things constant, by more than twice as much as father's literacy.

2. The direct effect of household per capita cereal consumption on children's nutrition is small but statistically highly significant. But in a period of famine when there is a large reduction in the consumption level, the impact could be sizable. Millet price plays an important role in grain consumption (Table 61) and thus affects child nutrition in the expected way.

3. A large marginal effect is shown by the meal frequency variable, which separates households that had less than three meals a day at the time of the survey. This can be viewed as an indicator of severe absolute poverty. Fourteen percent of these children from such households in the sample who registered, holding other things constant, were one-quarter Z-score below the others.

Table 60—Determinants of child nutrition: list of variables

Variable	Variable Definition	Mean	Standard Deviation
WAZ	Weight-for-age	-1.50	1.19
SEX	Sex (male = 1)	0.51	0.50
KIDAGE	Age of child in months	29.97	17.62
KIDAGESQ	Age of child squared	1,209.04	1,099.05
METHAGE	Child birth certificate (yes = 1)	0.30	0.46
MOTHAGE	Mother's age in years	29.46	6.14
MSTATUS	Mother's marital status (1 if married)	0.97	0.18
MAOCCUP	Mother's occupation	0.22	0.42
SIZE	Household size	7.21	3.09
SIZESQ	Household size squared	61.02	66.79
TOTKIDS	Number of children under five years	1.82	0.66
LNGRCAP	Log of grain consumption per capita	5.95	0.43
MEALLT3	Less than three meals per day (1 if true)	0.14	0.35
MOTHLT	Mother's literacy (yes = 1)	0.21	0.41
FATHLT	ather's literacy (yes = 1)	0.46	0.50
DIARNOW	Diarrhea at present (yes = 1)	0.20	0.40
INFECT	Prevalence of infectious diseases (scaled 0-5)	3.07	1.31
HLTHSERV	Distance to health center or hospital (scaled 1-4)	2.53	1.32
PIPEWTR	Piped water availability (yes = 1)	0.30	0.46
ASSCMN	Community participation (yes = 1)	0.33	0.47
MECHY	Mechanized rainfed agriculture area (yes = 1)	0.11	0.31
IRRGY	Mechanized irrigated agriculture area (yes = 1)	0.26	0.44
ROUND3	Season representative survey round 3 (1 if January-March 1987)	0.50	0.50
IMIGNEW	Number of immigrants	1.47	6.21
EXMIGNEW	Number of ex-migrants	0.51	2.51
DURAPR	Village average price of *dura*	156.20	30.78
DEPRATIO	Dependency ratio	0.22	0.12
DIARPRE	Predicted DIARNOW	0.21	0.03
LGRPRE	Predicted LNGRCAP	6.04	0.12

Table 61—Model analysis on determinants of nutrition: predicted grain consumption

Variable	Variable Definition	Parameter Estimate	t-Value
EXMIGNEW	Number of ex-migrants	-3.38204	-9.186
SIZESQ	Household size squared	0.38003	11.962
MSTATUS	Mother's marital status (1 if married)	-11.25482	-2.142
DURAPR	Village average price of *dura*	-0.27318	-8.656
IRRGY	Mechanized irrgated agriculture area (yes = 1)	-29.45766	-13.195
IMIGNEW	Number of immigrants	-0.14535	-0.978
MECHY	Mechanized rainfed agriculture area (yes = 1)	-30.53279	-9.729
MOTHLT	Mother's literacy (yes = 1)	-46.51363	-17.854
ASSCMN	Community participation (yes = 1)	-10.45667	-4.967
DEPRATIO	Dependency ratio	45.38720	4.545
FATHLT	ather's literacy (yes = 1)	-11.18718	-5.270
SIZE	Household size	-13.77757	-17.333
Constant		571.55591	63.254
$\bar{R}^2 = 0.072$			
Degrees of freedom: 29,960			
F = 193.8			

Table 62—Model analysis on determinants of nutrition: predicted child health

Variable	Variable Definition	Parameter Estimate	t-Value
MOTHLT	Mother's literacy (yes = 1)	-0.02304	-3.460
MSTATUS	Mother's marital status (1 if married)	0.03353	2.556
IMIGNEW	Number of immigrants	2.062222E-03	5.603
IRRGY	Mechanized irrigated agriculture area (yes = 1)	8.472184E-03	1.517
PIPEWTR	Piped-water availability (yes = 1)	-0.04651	-8.130
FATHLT	Father's literacy (yes = 1)	-0.01052	-1.982
Constant		0.19128	14.926
$\bar{R}^2 = 0.006$			
Degrees of freedom: 29,791			
F = 28.8			

4. Besides the food-shortage indicator of less than three meals a day, the diarrhea variable is the most powerful for child nutrition. Piped water reduces diarrhea substantially, but irrigation was not found to increase it (Table 63).

5. A better community health and sanitation environment would make a difference for child nutritional status, as indicated by the piped water working through reduced diarrhea to reduce malnutrition. A closer health service facility also contributes to improved nutritional status.

6. The agricultural production environment does not have a significant impact on the nutritional indicator directly. However, households' food consumption worsens in both mechanized rainfed and irrigated agricultural environments, and this does translate into a worse nutritional outcome (see Table 61).

Table 63—Model analysis on determinants of child nutrition status

Variable	Variable Definition	Parameter Estimate	t-Value
DIARPRE	Predicted DIARNOW	−1.53466	−5.527
SEX	Sex (male = 1)	−0.03424	−2.699
MEALLT3	Less than three meals per day (1 if true)	−0.27623	−15.010
ROUND3	Season representative survey round 3 (1 if January-March 1987)	0.12222	9.381
MOTHAGE	Mother's age in years	5.307271E-03	4.588
MAOCCUP	Mother's occupation	0.05553	3.527
INFECT	Prevalence of infectious diseases (scaled 0-5)	5.697872E-03	1.150
KIDAGESQ	Age of child squared	1.290052E-03	56.539
SIZESQ	Household size squared	−1.10861E-03	−4.628
METHAGE	Child birth certificate (yes = 1)	0.16518	10.276
HLTHSERV	Distance to health center or hospital (scaled 1-4)	−0.02522	−4.695
FATHLT	Father's literacy (yes = 1)	0.11184	7.154
MOTHLT	Mother's literacy (yes = 1)	0.28782	10.784
LGRPRE	Predicted LNGRCAP	0.87774	6.712
SIZE	Household size	0.04251	6.184
KIDAGE	Age of child in months	−0.09098	−63.977
Constant		−5.87219	−7.128
$\bar{R}^2 = 0.159$			
Degrees of freedom:	28,709		
F = 340.8			

Note: The consumption and health variables are predicted.

Important policy conclusions emerge from these findings: (1) The acute food shortage problem remains a major concern in a significant proportion of households. Even in a good year, as in 1986/87, the hunger problem was widespread and the relationship to child nutrition was strong. Creation of effective demand through employment creation and a host of measures to generate and transfer purchasing power to the poor is necessary; (2) improvement in community health and sanitation environment goes a long way toward nutritional improvement. The short-term diarrhea problem needs to be addressed in this context; and (3) rapid improvement in human capital, especially formal education, promises high returns in nutritional improvement through both the productivity and income effects.

Public action is called for in all three of these areas. Although the effects are partly long term, this action needs more urgent attention now, since household-response capabilities have been exhausted and community services eroded by the famines of the 1980s.

7

PAST POLICIES AND PROGRAMS FOR COPING WITH DROUGHT AND FAMINE

Sudan's experience in the 1980s has demonstrated the strong link between drought and famine in an environment where the agricultural resource base is poor, asset and income levels are low and variable, and public preparedness is lacking. The absence of public policy and institutional capacity to predict, prepare, and intervene was notable in view of the country's long history of drought-related famines and its past record of successful application of legislated famine prevention policy (famine codes). The lessons of 1984-85 appear to center on the public realization of the need to improve the production and income base of the rural population; to moderate fluctuations of production, prices, and income; and to establish a permanent institution to deal with relief and rehabilitation. This study underlines the key policy choices and views development, relief, and rehabilitation as integral components of a broad framework of famine prevention and preparedness.

It is argued in this study that famine events in Sudan are very much the result of short-term policy failures and market imperfections arising in a difficult-to-manage agroclimatic environment, fostered by deficiencies in long-run economic strategies. As was argued at the outset, the drought-famine relationships need to be assessed in a broader economic-policy context. The short-term crisis events are to a large extent the result of long-term policy failures, especially those related to agriculture. Therefore, this chapter first presents an overview of the long-term policy environment. Next, attention is drawn to relief policies for famine prevention in Sudan earlier in this century. The conclusion of the analysis is that it is largely policy failure that makes drought the triggering factor for famines. Dealing with drought, however, poses a major challenge to policy.

Economic Plans and Programs without a Strategy

Following independence in 1956, Sudan continued its policy of promoting production for export in the high potential riverine lands of central Sudan. Irrigated agriculture continued to be organized along the structure set in the Gezira scheme in 1925, where the sole priority was cotton production. This approach continued with the nation's first Economic and Social Development Plan, which came into effect in 1961/62 for a period of 10 years (see Wohlmuth 1987 and D'Silva 1985 for a review).

Parallel to the expansion of irrigated agriculture, there was spontaneous growth in private mechanized farming in the dryland of Eastern and Central regions. The government established the Mechanized Farming Corporation in 1968 to streamline, regulate, and provide support for expansion of mechanized agriculture. Large-scale privately financed mechanized farming was considered an important and quick means of promoting agricultural production in a country where land was assumed to be abundant (Elhassan 1988).

The subsequent plan, which was set for a five-year period (1970/71-1974/75), continued the emphasis on irrigated and mechanized agriculture to accelerate cash- and food-crop production in high-potential areas. Agricultural policy took a more aggressive turn in 1973, when the government introduced an interim action program that modified the original plan. With high prospects and commitments for large inflows of capital from Arab countries that prospered from the oil boom of the mid-1970s, and with Sudan's assumed great potential to produce an exportable surplus to meet its food import needs, the government embarked on a drive—the "breadbasket strategy"—to promote agricultural production and agro-industrial products. Development expenditures allocated to these projects greatly increased from SD£42 million to SD£102 million in the single year between 1973/74 and 1974/75. Nearly two-thirds of the expenditures were foreign-financed, largely from Arab funds.

The drive for the breadbasket strategy got a further push in the following Six-Year Plan (1977/78-1982/83), when the desire to attain self-sufficiency in selected food crops, particularly in wheat and sorghum, was articulated. The government's Food Investment Strategy of 1977 set this goal and called for the infusion of large-scale private capital into mechanized farming. In addition, the Six-Year Plan aimed at enhancing the speed and capacity of the agricultural sector to increase production and expand the export base to meet food demands in the Arab world. The Arab Fund's Basic Program for Agricultural Development for 1976-1985 provided the basis for the evolution of the production structure. The program's goal was to make Sudan a major exporter of sugar, wheat, oilseed, meat, fruits, and vegetables (Adams and Howell 1979).

An important departure of the Six-Year Plan, compared with its predecessors, was its recognition of the importance of traditional smallholder agriculture and the call for a parallel development strategy that would continue development of irrigated and mechanized agriculture and stimulate traditional crop and livestock production. In practice, however, the process meant an infusion of projects to mechanize traditional agriculture and establishment of modern ranches and large agricultural cooperatives (Adams and Howell 1979). The policy, in effect, resulted in mechanization of some selected high-potential areas.

The Six-Year Plan was abandoned a year after its inception as the country's economic crisis deepened and its planned growth got off track and was unsustained. Economic growth, which registered rapid rates of increase in the mid-1970s, started to taper off in 1977. The economy declined at an annual rate of −1.6 percent in 1977, followed by −10.4 percent in 1978 (Table 64). The substantial inflow of capital from Arab countries peaked in 1974/75 and tapered off in the second half of the 1970s.

The government, constrained by low public savings, turned to borrowing from the Central Bank to finance its mounting deficits. Central Bank financing of the overall public deficit reached 97 percent in 1977/78. The growth rate of money supply surged from 19 percent in 1974/75 to 31 percent in 1978/79. The average

Table 64—Macroeconomic indicators for selected years, Sudan

Indicator	1973/74	1974/75	1977/78	1978/79	1980/81	1982/83	1984/85	1985/86
Growth rate of real GDP (percent/year)[a]	10.2	6.7	−1.6	−10.4	2.2	3.3	−14.4	9.3
Overall public deficit (percent of GDP)	1.1	4.4	5.2	9.4	13.2	7.9	15.9	12.7
Share of development expenditure (percent of GDP)	3.4	6.8	6.5	5.1	5.8	4.5	3.4	1.7
Growth rate (percent/year)								
Money supply (M2)	29	19	26	31	38	42	59	32
Inflation rate[b]	25	23	20	32	24	31	46	29
Index								
Real exports	100	102	75	66	69	75	55	38
Real imports	100	154	126	108	128	166	80	62
Real exchange rate[c]	100	109	123	141	132	74	106	n.a.

Sources: World Bank, *Sudan: Prospects for Rehabilitation of the Sudanese Economy*, vols. 1, 2, and 3 (Washington, D.C.: World Bank, 1985); World Bank, *Sudan: Problems of Economic Adjustment*, vols. 1, 2, and 3 (Washington, D.C.: World Bank, 1987); and Bank of Sudan, *Annual Report* (Khartoum: Bank of Sudan, 1980-86).

Note: n.a. means not available.

[a] GDP refers to real gross domestic product in 1981/82 prices.

[b] Based on simple average of cost-of-living indices for low- and high-income groups.

[c] Nominal exchange rate adjusted for different inflation rates between Sudan and the United States.

inflation rate rose from 23 percent to 32 percent over the same period, partly because of an easy monetary policy. Moreover, the economy failed to meet the excess demand that was partly fueled by the expansionary investment program and the lag in the supply response of new projects. Increases in petroleum and petroleum products prices also contributed to the increase in the general price level. The sluggish export performance, particularly of cotton, in the 1970s, coupled with rising import bills, precipitated large deficits in the trade balance. The nation's capacity to service its external debt obligations shrank in the face of its worsening capacity to raise foreign exchange either through trade or capital inflows. In the late 1970s the mounting disequilibria in both internal and external balances obliged the government to enter into a stabilization and adjustment program designed by the International Monetary Fund/International Bank for Reconstruction and Development.

This program, which started primarily as a stabilization scheme in 1978, expanded into a comprehensive Economic Recovery Program in 1980. The program goals were to accelerate agricultural production, especially export and import-substituting crops, close the budget deficits, cut the rising inflation rate, and improve the capacity to earn the foreign exchange to repay the mounting external public debts. A combination of fiscal, monetary, exchange-rate, price, trade-liberalization, and institutional-reform policies was instituted. The fiscal policy comprised measures to cut as well as to reprioritize government spending and to enhance revenue generation. Monetary measures involved setting targets for credit and money supply and limits to public borrowing as well as alignment of nominal interest rates with rising price levels. The exchange rates were set to be devalued and unified to encourage growth of tradable production sectors, especially those involved in the production of export commodities. Other policy measures included deregulation of prices and liberalization of trade to create an economic environment conducive to greater participation by the private sector. The government pursued these policies within the framework of a rolling three-year public-investment program.

An Agriculture Rehabilitation Program was integrated as a component of the economic recovery program. It placed a heavy emphasis on the country's capacity to generate foreign earnings through the export of cotton. This was to be achieved through the completion of ongoing viable projects, rehabilitation of existing production capacity, and improvement of the incentive and income-sharing arrangements of cotton producers in the irrigated schemes. The prime target was the irrigated subsector, which was assumed to yield quick economic returns. However, the program noted the high potential of the rainfed-agriculture sector to stimulate the economy and called for devising a strategy for the development of this sector.

The recovery program continued for seven years until 1985, when it was suspended by a new military government. It was replaced by the annual development plan for 1985. The abandonment of the recovery program was related to its failure to ameliorate the worsening economic situation of the country, which was accelerated by drought in 1984. Macroeconomic indicators for 1984/85, for instance, show that real GDP fell 14.4 percent, and the public deficit registered as 16 percent of GDP. The annual inflation rate reached 46 percent and thus contributed to an appreciation of the real exchange rate—changes in the nominal exchange rate did not translate into real devaluation, at least in 1984/85. The macroeconomic development and failure to implement comprehensive reform—including moving to a market-oriented exchange rate—have been identified as major underlying causes of the increased famine vulnerability of the Sudanese economy (Atabani 1991).

Views differ on the factors that contributed to the ineffectiveness of the recovery program (see Brown 1986 for a review). The donor community associates the poor performance with shifts in government priorities and adherence to partial programs and piecemeal measures. Such government behavior might have resulted from the debilitating effects of three years of continuous droughts, the so-called Islamization program (which included abolition of income taxes and interest rate charges), the war in the south, and concern for the political repercussions of some of the measures. Advocates of the more structural approach consider the policy package of the recovery program to have been irrelevant or insufficient to solve the deep economic crisis.

The civilian government that came to power in 1986 introduced the Four-Year Economic Salvation, Recovery, and Development Program, which, like previous economic development efforts, had the broad objective of achieving sustained economic growth and effectively boosting real per capita GDP. The agricultural sector's role was considered to be of prime importance—increased agricultural production would spearhead the growth process. The program also incorporated goals of income and wealth redistribution and food security for rural and urban populations. In contrast to the previous economic development plans, the 1986 program, drawn in the aftermath of the country's bitter experience with the 1984-85 famine that revealed its vulnerability, recognized the need not only for adequate food production but also for an operationally efficient food-distribution system.

Economic Deterioration and War

Successive governments have relied heavily on partial solutions and economy-wide controls to suppress excess aggregate demand. More important, the food and agricultural policies pursued in Sudan so far have concentrated on the irrigated agriculture subsector and large-scale mechanized farming to the neglect of traditional, smallholder agriculture.

This is all against the background of continued conflict and war. The country has been engaged in a protracted war since 1955, though there was a 10-year spell of peace from 1972 to 1983. As a result of the war, millions of rural people have been displaced and forced to migrate, leaving their homes and changing from producers to net receivers of food relief. Production has been disrupted and employment opportunities have diminished (there is no war machinery creating a short-term war boom).

Relief Policies and Responses

Sudanese records show that the country has a long history of recurrent famines. Except for the period between 1920 and 1956, public response to prevent and contain famines has been nonexistent. The rural population has had to depend largely on their own resources and coping strategies. Such capabilities, however, have been threatened in recent years, particularly in the aftermath of the 1984-85 famine, because of greatly reduced asset bases of the rural population and increased volatility of employment, income, and food prices in rural areas. Medium- and long-term programs aimed at durable solutions need to be initiated to reverse the present trends, stabilize the population of the affected areas, and create sustainable environments. Accordingly, a new approach is needed; yet, some lessons from Sudan's own past experience are worthy of remembrance.

Colonial Famine Policy

The colonial famine policy in Sudan was much influenced by the British experience gained in India. In India, detailed famine legislation had been drawn up during the second quarter of the last century. These famine codes focused on earlier identification of the risks of famine, the provision of employment and public work schemes for those who can work, and food distribution to those unable to work (Drèze 1988).

The British administration in Sudan induced the establishment of a similar approach to famine policies. National famine regulations were actually drawn up after the First World War (1920) and guided government actions in cases of famine during the next three decades (Shepherd 1988). The regulations embodied three cardinal guiding principles: the government should respond promptly to provide relief to those in need; relief should be in the form of provision of employment to those able to work; and free food should be distributed to those unable to work.

The 1920 famine codes outlined the process of discovery, preparedness, and intervention in times of threat or actual famine. The components of governmental reaction to famine are very similar to today's components of a disaster relief policy. The main components were (1) discovery of threat of famine through a system of intelligence gathering including personal inspection; (2) preliminary measures of preparation, which included, among others, validation of information, selection of programs and sites for relief work, and tests to see if there was actual famine. The tests involved provision of public works at low wages and under hard conditions; (3) immediate implementation of a relief program, as soon as the existence of famine was declared, that included the provision of work for the able-bodied and free food for those unable to work; and (4) detailed inspection of relief work and assessment of the effectiveness of the relief program.

The famine regulations, which were in effect between 1920 and 1956, were instrumental in preventing major famines. They were applied "almost fifty times in different areas of Sudan" during this period (Pearson 1986). Actions taken to prevent famine became routine features of famine administration (Shepherd 1988).

Food Aid and Relief Management, 1984-88

Between the mid-1950s and early 1980s, there were no special institutions that handled antifamine work. Even though no major food crisis developed in these years, the Sahel drought of 1968-73 had a localized impact, particularly in the west. Because of the abandonment of the earlier relief regulations without substitution of a viable national policy to prevent famine, the rural population had to resort to their traditional coping mechanisms. The government's failure to maintain and further improve the earlier famine-prevention policies proved very burdensome for the rural population. The droughts of 1982-84 and the great famine of 1984-85 revealed the limits to the ability of the rural population to subsist on its own.

The onset of the 1984-85 famine was noted as early as 1983. People moved on a permanent basis from the drier areas of Northern Kordofan and Northern Darfur in 1983. The governors of the western and eastern provinces appealed to the central government in late 1983 and early 1984 to provide relief support. The government response was slow and ad hoc (banning of sorghum exports in March 1984, increase of area under sorghum cultivation in the irrigated areas, and shipment of 5,400 tons of sorghum to the west in April/May). The lack of sufficient response from the central government prompted the governor of Darfur to resign in April 1984. Except for some sorghum that reached western Sudan in late 1984, relief activity gathered momentum and peaked in May/June 1985—several months after the appeal by the governors for emergency support.

There were three principal waves of food aid to western Sudan in the 1980s in response to major crop and income failures. The first and major food-aid flow was initiated in 1984-86. Another crop failure was experienced in 1987, prompting a second relief flow in 1988. The good crop year of 1988 was followed by two consecutive years of bad harvests, which called for a third wave of food aid.

Kordofan received a total of 331,300 tons of cereal food aid in the 1984-86 period (Table 65). The flow of food aid dropped to 32,100 tons in 1986/87 but recovered to about 72,000 tons in 1988.

A series of administrative committees were established in Kordofan by the end of 1984. A high-level policymaking relief committee was established in August

Table 65—Delivery of relief food to Kordofan, 1985-88

Year	Commodity	Quantity	Government Share
		(1,000 metric tons)	(percent)
1985	Sorghum	195	11
1986	Sorghum	131	0
	Wheat and wheat flour	55	. . .
	Supplementary feeding	12	. . .
	Others	9	. . .
1987	Sorghum	32	37
1988	Sorghum	72	44

Source: Based on data from the Regional Food Aid Administration Office, El Obeid.

1984. It was responsible for setting up plans, strategies, and policies to mobilize resources and to guide and supervise relief work. Technical committees were set up at the regional and local levels to implement the 1984/85 relief operation. An office of Regional Food Aid Administration (RFAA) was created in August 1984 to administer food aid in collaboration with the technical committees.

The donor community took a leading role in relief operations in 1985/86. The Relief and Rehabilitation Commission, which had been created in mid-1985 (see Appendix), was not yet in a position to provide effective institutional support. Food delivery was undertaken largely by donors with assistance from foreign nongovernmental organizations (NGOs). In Kordofan, the NGOs operated within specific zones under the umbrella of RFAA and the technical committees. For example, CARE operated in Sodari, Bara, En Nahud, and El Obeid districts, Save the Children Fund/USA in Um Ruwaba district, and Sudan Aid in northern En Nahud.

This parallel structure was abandoned at the end of the 1984-86 relief operation. The RFAA office in Kordofan took responsibility for the distribution and management of relief work in 1988 (Buchanan-Smith 1990). The local technical committees were used as vehicles for delivery of relief food to the recipients. The donors monitored and supervised the relief work through a privately contracted firm.

Intraregional relief food allocation was largely based on assessment of area specific needs. For 1984/85, districts in Kordofan were ranked according to crop production record, scale of out-migration, anthropometric measures of nutritional status, and reported mortality rates. The RFAA office adopted 450 grams per person as a minimum full quota per day. Varying fractions of the full quota were then applied to the districts to reflect these rankings. A maximum allocation per family was set, based on the assumption that no family had more than six members.

For 1985/86 and 1986/87, the concept of a subsistence gap was applied as a measure of need. Districts were ranked according to the estimated percentage of the subsistence gap. Rural councils within specific districts were allocated a variation of the district-specific quota in accordance with their rankings. To determine its relief needs for 1987/88, Kordofan was divided into three crop-risk zones. Risk was defined in terms of the extent of expected crop failure. The full quota was then assigned to areas in the complete crop-failure zone. In effect, the methodology of food assessment in 1988 regressed as compared with the food-balance approach adopted in 1986 and 1987.

At the household level, allocation within specific target areas was based on the principle of equal distribution. That is, resident families within specific food-target areas were equally eligible for distribution. Priority was accorded to all who stayed in their place of residence during the operation, including those in towns. Except for a small share of the quota that was monetized, food was largely distributed free.

Food aid reached a high percentage of the rural population in the 1984-86 operation, but there were notable deficiencies. Food aid arrived at the villages at different points in time. In some of these villages the severity of the food shortage reached its peak in the months preceding the arrival of food aid (Table 66). When the waiting period was too long, a village would move en masse in search of work and relief. The poor timeliness was partly related to the fact that food allocated to the region was not delivered on schedule.

Food aid that was actually delivered was often much less than the planned, area-specific ration (Table 67). Two important factors explain such below-target delivery. First, food allocated to the region was not sufficient to meet the planned distribution. Second, there were considerable losses due to wastage and leakage. For example, combining the lower-than-target allocation and underweight factors, the total sorghum available for the May-October 1985 allocation was sufficient only for a 3.3-month allocation.

The original allocation plan of "equal per capita" was not observed. For example, there were significant intervillage variations in actual per capita distribution within the same district (Table 66). These variations were related to irregularities in the timing and frequency of food-aid flows across villages. In addition, there

Table 66—Relief food arrival time, amount distributed, and frequency in sample villages of Northern Kordofan, 1984/85

District/Village	Peak Hunger Period	Relief Food Arrival Time	Amount Distributed per Ration	Delivery Interval
	(month/year)	(month/year)	(kilograms/person)	(days)
Bara				
El Genena	September 1984	February 1985	9	30 – 45
Um Sereha	October 1984	February 1985	9	30 – 45
Um Sot	October 1984	February 1985	12	30 – 45
El Obeid				
Abu Khrais	November 1984	December 1984	4.5 – 6	30 – 40
El Liwab	December 1984	February 1985	4.6 – 6	30 – 40
El Tina	November 1984	May 1985	6	30 – 40
Um Ruwaba				
El Felia	October 1984	November 1984	3 – 6	30 – 90
Wed Eldeik	August 1984	October 1984	n.a.	n.a.

Source: International Food Policy Research Institute survey, 1989.
Note: n.a. means not available.

Table 67—Food aid targeted and received in districts of Northern Kordofan, May-October 1985

District	Target Delivery	Amount Received	Percent of Target Population
	(grams/capita/day)		
Sodari	450	213	21
Bara	400	364	15
En Nahud	400	180	67
El Obeid	350	288	91
Um Ruwaba	350	132	20

Sources: OXFAM-UNICEF and Kordofan Regional Government, "A Report on the Nutritional Status of 1,888 Children in Kordofan, February/March 1985"; "The Nutritional Status of Children in Kordofan, May/June 1985"; "The Nutritional Status of 4,575 Children in Kordofan Region, September/October, 1985"; and "The Nutritional Status of 3,183 Children in Kordofan Region, March 1986" (mimeographed).

was less adherence to the application of a uniform quota—the premium (such as malnutrition or migration) of getting food aid was much higher for the remote villages.

No household-specific data exist on distribution of relief food within villages Recall-based information indicates sizable intravillage variations, although families were supposed to share equally. Part of the problem can be ascribed to the design of the food-aid policy. The food ration per family was based on two key assumptions—equal weight for every member in terms of food requirement and a maximum family size of six members. The ration per family thus had an inherent bias against large families, particularly those with a high proportion of adult members. Furthermore, the application of universal eligibility (except the nonresidents) fails to recognize food aid as one of several coping instruments. Families are unequal in terms of their coping capacity.

It is probably valid to argue that the relief policy was less favorable to the poor. The original plan to extend relief only to those who had no resources failed for lack of sufficient information and political sensitivity. The residence requirement for eligibility must have significantly excluded the poor from the distribution. Most of those who migrated earlier were probably among the poor. The two-tier distribution modality (free distribution and cash payment at a subsidized price) was also unfavorable to the poor. In the absence of a program to augment their income, the poor could not effectively participate in the monetization scheme.

Building Coping Capacity: Selected Project Experiences

The year 1985 witnessed a large-scale famine relief operation in western Sudan. By 1986, the regional government of Kordofan had developed a rehabilitation strategy based on the concept of a zonal framework (KRMFEP 1986). The region was divided into three zones (northern, transitional, and southern), then subdivided into six zones. The zones were designed to show low intrazone but high interzone variability in their ecological features, potential agricultural base, and population settlement.

The plan identified strategies applicable to all as well as to specific zones. The primary goals were to restore the degraded natural environment through rehabilitation of forest and natural pasture, to improve availability and distribution of rural water supply, to promote agricultural production and income, and to provide support for households targeted for resettlement or reconstitution of their asset base. The relative emphasis of these goals varied across zones.

A sample of ongoing rehabilitation projects in the region is shown in Table 68. They show considerable comparability to the priorities set for the region. The projects cover rehabilitation of land and water (such as restocking of gum arabic

Table 68—Sample of ongoing rehabilitation activities in Northern Kordofan, 1988/89

Intervention Program	Source/Sponsor[a]	Target District	Target Group
Smallholder credit for cash-crop production	ABS/USAID ABS/Sudan ABS/SCF ABS/IFAD CARE/Netherlands	El Obeid Um Ruwaba Um Ruwaba En Nahud En Nahud	Villages selected on the basis of high production potental; membership open to farmers with access to land and proven repayment capacity
Restocking of gum arabic trees and other forestry[b]	UNSO/WFP/UNDP	Um Ruwaba El Obeid Bara	Villages with low acacia sengal tree coverage are selected. Open to farm families who own land, work on farm, and reside in the villages
Restocking of small animals (mainly goats)	UNICEF[c]	Bara El Obeid	Low-income women with no livestock
	OXFAM	Sodari	Nomadic families with no more than five goats or sheep
Home garden development	UNICEF	El Obeid	Low-income women
Irrigated agriculture	UNICEF	Bara	Low-income women
Grain storage (village level)	UNICEF	El Obeid Bara	Low-income women
Cheesemaking	UNICEF	El Obeid	Low-income nomadic women

[a] ABS = Agricultural Bank of Sudan; USAID = United States Agency for International Development; SCF = Save the Children Federation; IFAD = International Fund for Agricultural Development; UNSO = United Nations Sudano-Sahelian Office; WFP = World Food Programme; UNDP = United Nations Development Programme; UNICEF = United Nations Children's Fund; OXFAM = Oxford Committee for Famine Relief.

[b] CARE/Canada in En Nahud district, SCF/US in Um Ruwaba, UNICEF in Bara and El Obeid, and ILO (International Labor Organization) in Bara operate small-scale forestry projects.

[c] UNICEF also undertakes other projects such as poultry, mechanized farming, composting, seeds, beekeeping, handicrafts, adult education, and village water supplies throughout Kordofan Region.

trees), asset reconstitution (such as restocking of goats), and promotion of agricultural production (for example, through provision of production credit).

These microprojects are not expected to reverse the process that has rendered the rural economy vulnerable to a recurrence of famine. But they are likely to facilitate and contribute to the establishment and protection of the coping capacity of the famine-prone population. Selected cases of such intervention programs are examined here to learn from their experiences and to draw lessons that should be incorporated in devising a strategy for famine prevention in the drought-prone areas. The case of the Jebel Marra Rural Development Project in Darfur is added to the review of Kordofan-based projects. It highlights the importance of technological change in agriculture as a source of growth and an income buffer in time of crisis.

Food-for-Work Planting: The Gum Belt Project

The gum belt of Kordofan stretches from west to east within the Sahelian zone and contributes nearly 50 percent of the world's production of gum arabic. Typically, farmers in the gum belt maintain gum gardens as part of their traditional agroforestry practices. The gum trees, acacia senegal (*hashab*) in particular, play a central role in maintaining the agro-ecological balance in the otherwise delicate and fragile ecological zone. In addition, the trees provide direct income to the farm population.

Gum production steadily declined in the 1980s, reaching its lowest point in 1984 (Table 69). A continuous aridity in the 1970s and 1980s, unfavorable official producer prices, and the frequent dependence of the rural population on income from tree products (charcoal and firewood) as a fallback in times of crop failure contributed to a combined outcome of decline in tree density and productivity. There is now marked evidence that the gum belt is shrinking, at least on its northern frontier.

The areas that require the greatest tree coverage are the most exposed to desertification. Such recognition has prompted various levels of response for rehabilitating the gum belt, especially since the 1984 drought. A joint United Nations Development Program and Government of Sudan project began in 1981 to rehabilitate the Kordofan gum belt. The primary goal of the project is to halt degeneration of the environment, but it has secondary goals of creating additional employment and improving the income position of participating farmers.

Table 69—Index of gum arabic production, 1974-87

Period	Production	Index
	(1,000 metric tons)	
1974-78	39.3	100
1980-81	34.0	87
1982-83	32.8	83
1984	14.1	36
1985-87	25.2	64

Source: Based on data from the Gum Arabic Company, Khartoum.

The framework for implementation of the Gum Arabic Restocking Project is based on central nurseries that serve satellite villages in their designated areas. Nurseries are selected on the basis of proximity to a permanent water source, road accessibility, and density of settlement. Each nursery serves a selected number of villages. Farm households are selected from participating villages. Village committees serve as the entry point for participating farmers.

The central nurseries produce and multiply seedlings, and the project delivers the seedlings. In addition, it sells water at a subsidized rate to water-deficit villages and delivers food rations. By mid-1989, the project had covered about 12,000 farmers in nearly 300 villages (Table 70). In the first three years, the project covered on average 27 villages per year at a rate of 29 farmers per village. There was a jump in the rate of coverage in 1984 and 1985, mainly in the average number of villages. Since 1985 there has been an increasing demand for expansion of enrollment. The integration of food aid into the project package, the realization of improved prospects for better gum prices, and increasing awareness of the project's desire to revitalize the environment are presumed to contribute to this surge in demand. The project management has shown some flexibility in its rules, at least in raising the quantitative quota per village since 1986. But, because of resource limits, the management exercises administrative rationing to restrict enrollment.

Project reports indicate that effective tree coverage due to the project averages 141 trees per feddan (338 trees per hectare). This amounts to about 57 percent of the recommended planting rate. Findings in IFPRI survey villages concur with the observed rate of low survival. On average, the low-density villages in Table 71 in fact show a much lower survival rate. In addition, data from El Obeid and Bara villages show emerging patterns. First, there are considerable variations in gum output per farm across villages due to variability in tree density, age specificity of tree productivity, and fractions of trees tapped and harvested. Second, project fields have a relatively high tree density compared with traditional *hashab* fields. Third, the short-term employment effect of the project appears to be modest. Fourth, the food ration is the only source of variation between the income sources of participants and nonparticipants. A low income share from gum production is largely

Table 70—Trends in gum belt project participation, 1981-88

Year of Initial Participation	Number of Villages	Number of Farmers	Number of Farmers per Village	Seedlings Produced
		(new participants)		(thousands)
1981	25	673	27	990
1982	27	756	28	1,100
1983	29	915	32	1,240
1984	39	1,479	38	1,840
1985	46	1,651	36	2,375
1986	37	2,107	57	2,849
1987	39	2,172	56	3,090
1988	30	1,765	59	3,320

Source: Based on data from the Department of Forestry, El Obeid.

Table 71—Density, farm size, and yield for low- and high-density farms in gum belt villages, 1989

	Gum Belt Project Farms		
Item	Low-Density Villages	High-Density Villages	Traditional Hashab Garden (Genena)
Trees/hectare	173	332	110-140
Farm size (hectares)	2.9	3.2	4.4
Yield (kilograms/tree)	0.34[a]	1.04[a]	1.04-1.59-1.13[b]
Fraction of gum-producing trees/year[c]	0.13	0.30	n.a.

Source: International Food Policy Research Institute survey, 1989.

Note: n.a. means not available.

[a] Mean yield of a young tree under the project.

[b] Yield varies by age of tree; it is low in early years (6-8), peaks in middle age (9-12), and drops in later years (13-18). No consensus has been established as to whether the yield in old age is higher or lower than when young, even though most tend to suggest the older trees yield better.

[c] On average, 50-60 percent of trees are tapped every year.

expected, given that the trees take six to eight years to mature and most of the villages were not ready to tap in 1988. The benefits of the project are of course larger in the long run as trees move into their peak productive age cycle and other crops benefit from improved soil fertility and moisture.

At the project level, the management should adhere to the primary goal of pursuing a wide coverage of area through promotion of a minimum recommended planting rate. In the short run, given the scale of the project, one option for broadening the scope of participation is to modify the modality of the project operation. It can, for example, focus on a "model farmer" approach, where groups are formed around model farmers, seedlings are provided to groups on a rotating "credit" basis, and the actual allocation is conditional on the groups' performance. In addition, it is necessary to modify the current incentive structure to allow linkage of payments to task measures of output. Food must be linked to the task rate and limited to the preproduction phase.

Improved Agricultural Technology

Compared with the rest of Darfur, Jebel Marra and its surroundings represent an area of high agricultural potential. The area benefits from a long-term rural development project that has a component of agricultural-technology promotion. The extension of this technology has enhanced the production as well as the employment-absorption capacity of the Jebel Marra area in recent years.[8]

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[8] This section draws on the work of Graciela Wiegand-Jahn (1989). The research was a cooperative effort between IFPRI and the Jebel Marra Rural Development Project. All results presented in this section are derived from data sets provided by the Monitoring and Evaluation Department of the project.

In the early 1980s, the area experienced lower than usual rainfall. In 1984, as in much of western Sudan, the lack of rain was severe. The area had to cope not only with food shortages for its own population but also had to absorb a large number of refugees who came from areas that were even more affected (other parts of Darfur and Chad).

The drought of 1984, which led to a total crop failure in many parts of Northern Darfur, led to reduced production in the Jebel Marra project area. All villages in the project area experienced a drop in grain production, but villages that had access to modern inputs through extension services experienced smaller declines (Table 72). Within the participating villages, households with access to improved inputs and extension services achieved a higher grain output per capita and managed to produce enough to meet calorie needs.

A comparison of the participating and nonparticipating households shows that only a few households in the participating group had no male head in the drought year, while 50 percent of the nonparticipating households had to manage the drought year without a male head of household (Table 73). The relatively small fluctuation in household size and in percentage of female-headed households in the participating group over the years suggests that these households were in a much more stable position during the crisis year of 1984/85 than the nonparticipating households. Those without access to modern inputs produced less and had to manage by adjusting household size through out-migration of adult males. Coping was much easier for those participating in the project.

Typically, farmers from Northern Darfur come to the project area during the harvest period in search of employment. In 1984, a large number of refugees came to the area from places that were severely affected by the drought (Northern Darfur

Table 72—Grain production before, during, and after the 1984 drought, by participation in the Jebel Marra Project

	Grain Production per Household			
			Participating Villages	
Season (wet)	Participating Villages	Nonparticipating Villages	Participating Households	Nonparticipating Households
		(kilograms)		
1982/83	980[a]	520[a]	1,148[a]	779[a]
1983/84	973[a]	449[a]	1,361[a]	785[a]
1984/85	624[a,b,c]	220[a,b,c]	867[a,c]	544[a,c]
1985/86	1,844[a]	1,568[a]	2,082	1,745
1986/87	1,064	1,173	1,498	1,099

Source: Computed on the basis of Jebel Marra survey data.

Note: The village of Taij was excluded because of unusually high yields.

[a] The mean of the participating and nonparticipating groups was significantly different (t-test).

[b] The mean was statistically lower than in previous years (t-test).

[c] Per capita grain production in the 1984/85 season was 178 kilograms for participants and 75 kilograms for nonparticipants. There was no significant difference within participating villages. The same pattern appears when the comparisons are made on the basis of proportion of households with less than 1,000 calories per capita per day. The percentage was higher in nonparticipating villages (79) as compared with participating villages (41).

Table 73—Household size and percentage of female heads of household in extension villages of the Jebel Marra area

Survey Period	Participating Households		Nonparticipating Households	
	Household Size	Female-Headed Households	Household Size	Female-Headed Households
	(persons)	(percent)	(persons)	(percent)
Wet season, 1984/85	5.01	9	3.31	47
Postharvest, 1985	. . .	16	. . .	50
Postharvest, 1988	6.65	11	5.78	23

Source: Computed on the basis of Jebel Marra farm survey data.

and Chad). Most came to the project area in October and November 1984, around harvest time. Many settled around existing villages in the project area, in the fertile lower-valley zone that experienced a significantly better grain harvest than other zones in the drought year (see Table 74).

Improved agricultural technology was thus a powerful tool for mitigating the drought crisis. Given the mobility of labor in the region, a concentration of technological change in the comparatively high-potential area provided respite for drought refugees from a large surrounding area.

Credit for Production and Consumption

The Agricultural Bank of Sudan (ABS) initiated a cooperative-based credit program in El Obeid district in 1981/82 for production enhancement and consumption stabilization. The program caters primarily to the credit needs of small farmers in rainfed agriculture. ABS provides targeted loans to finance current production and storage.

Table 74—Distribution of refugees in Jebel Marra area, Darfur, by agro-ecological zone, 1984/85-1985/86

Zone	Village Population	Number of Refugees, 1984/85	Number of Refugees, 1985/86
Mountain	1,463	157 (11)	52 (4)
Upper valley	1,216	209 (17)	87 (7)
Lower valley	1,542	706 (46)	303 (20)

Source: Computed on the basis of Jebel Marra farm survey data.

Note: The numbers in parentheses represent the number of refugees in percentage of village population.

Village-based cooperatives that have a legal entity serve as a channel for delivery of credit and marketing services to small farmers. Each village can form one cooperative, provided that it has a minimum of 50 members. Membership is open to resident farmers who are over 18 years of age, and who have access to land and a sound credit record.

Each borrower is allowed to finance a fixed maximum area per crop. ABS determines the loan rate per area. The total loan per borrower is a function of the loan rate per area and the total area approved for financing. Production loans are disbursed in three installments. This strategy is intended to ensure that the loan is used for designated operations and to minimize the risk of loan default. ABS charges an administrative fee on its loaned funds.

ABS has so far reached a maximum of 21 cooperatives covering nearly 2,000 members per season (Table 75). A significant number of cooperatives were registered in the 1983/84 and 1984/85 seasons, the two drought years, but only a small fraction of them were financed. Despite an increase in demand for loans, ABS was unwilling to risk a high loan default rate. This is evident in the drop in the loan rate per area.

Available evidence of loan utilization shows that a large percentage of ABS loans are used for food consumption. Studies by the Kordofan Rainfed Agricultural Project and ABS (Technoserve/ABS/USAID 1987; Bielen, Crauder, and Rivarola 1989) show that 68 and 83 percent of the loans were used for food consumption in the 1986/87 and 1988/89 seasons, respectively. The IFPRI study shows an average of 73 percent for the 1988/89 season. No more than 20 percent is used for the purchase of current agricultural inputs and the cost of labor. Food is thus a top priority of ABS clients.

Loans are seldom recovered in full on the first due date (Table 75). Exceptions to this are 1988/89 and the early years. ABS was effective in its early years when loan size was small; however, high rates of current loan default occurred in the drought years from 1982/83 to 1984/85. The lowest on record was 1984/85, the peak drought year.

ABS's strict application of debt collection policy (no debt relief, no rescheduling of debts, and no new loans without a settlement of old loans) contributed to a recovery of its past loans in 1986/87 but drove out a large proportion of borrowers. Farmers express their reluctance to join ABS for fear of loss of income and assets in case of crop failure.

The weak performance of ABS in terms of its record of low profitability and an apparent decline in loan participation has raised serious doubts about its narrowly focused goal of financing agricultural production in such a highly volatile environment. There are serious questions to be dealt with. Should ABS broaden its mandate to contribute to improvement of the underlying conditions that cause production instability? Should ABS attach greater weight to farmers' expressed desire for income or investment diversification? Could ABS be used as a source of alternative financing in times of severe income failure in rural areas? ABS may not be particularly positioned to respond to these needs, but these are relevant points to be addressed in the context of drought-prone areas like Northern Kordofan.

Restocking of Livestock

The UNICEF goat-restocking project represents an asset-rehabilitation effort in a postfamine period. The project, which started in late 1986, caters to poor

Table 75—Cooperative credit program in El Obeid district, Kordofan: loan participation and performance, 1980/81-1988/89

Season	Cooperatives Financed	Cooperatives Financed as Percentage of Registered Cooperatives	Percentage of Members Financed	Area Financed per Borrower	Average Loan per		Recovery Rate at First Due Date
					Area	Borrower	
				(mkh)[a]	(SD£)		(percent)
1980/81	3	100	101	5.84	17.26	100.84	50
1981/82	11	100	94	6.44	29.73	191.46	62
1982/83	12	75	69	9.01	23.94	215.70	6
1983/84	20	77	71	8.96	25.04	224.36	12
1984/85	18	53	51	8.48	20.27	171.89	2
1986/87	11	32	22	7.31	33.11	242.03	19
1987/88	19	49	42	8.79	38.99	342.24	38
1988/89	21	54	41	9.66	66.04	637.98	82

Source: Based on data provided by the Statistics Unit of the Agricultural Bank of Sudan.

Note: The Agricultural Bank of Sudan extended credit mainly in the form of seeds in the 1985/86 season. This was not typical of any of the other years, when there was a nine-to-one ratio of cash to commodity package.

[a] One mkh (*mukhammas*) = 0.73 hectare.

female-headed households in the drier areas of Northern Kordofan, particularly in El Obeid (Um Esheria) and Bara districts. It was felt that income controlled by women had the greatest and most effective impact on child nutrition and health, and children of these households had become the most vulnerable in the postfamine period.

The project provides two breeding female goats to qualified participants. Eligibility for participation is conditional on proof of income and wealth status and written consent to abide by the rules of participation. Such rules include, among others, agreement to use goat products to feed the participant's children, to pay back two female offspring within a 24-month period, and to refrain from selling female goats to ensure growth of stock.

By the end of 1989, a total of 1,521 breeding female goats were distributed to 760 female-headed households, and another 248 goats were distributed to 124 participants from the collection of offspring from the original parent stock. By the end of 1989 the project had benefited 398 families in 10 villages in Bara district and 486 families in 11 villages in El Obeid (Um Esheria) district.

The IFPRI survey results indicate that participation in the project has apparent positive economic effects. Although ownership of livestock is generally low, families in the project appear to have more livestock. Ownership of goats has also contributed to improvement in income position. In addition, it has improved the relative income position of the participants. Twenty-seven percent of the project group belonged to the relatively high income position, compared with 10 percent of the control group. Such improvements in asset and income position have translated into higher levels of calorie consumption.

The project is under pressure to expand to meet a growing demand for participation. Given UNICEF's limited capital budget for the project, its future growth and sustenance depend on how fast it can promote expansion through progeny distribution. Crucial to such expansion is the performance of growth indicators, especially birth and death rates. The survey shows that there are sizable variations in these growth indicators across villages. The project lacks effective veterinary-service support to reach the participants. In addition, there are variations in the degree of monitoring and supervision of growth performance. Where such monitoring is lax, there is a tendency to underreport births, especially in the case of female offspring, in order to delay repayment. It is thus crucial that growth performance, monitoring, and supervision improve.

8

POLICY CONCLUSIONS

Drought-famine relationships are complex. Therefore, policy recommendations to deal with them are also complex and closely interlinked. Nevertheless, an attempt is made here to tie together the major policy conclusions of this study and to do so with a sense of priority for famine prevention.[9]

General Policy Priorities

Political Stability

The peaceful settlement of the conflict in the South is the most important element for the economic well-being of the whole country and for the most vulnerable groups in particular. Not only does the cost of war to human life continue to be high, but it has also led to the displacement of millions of rural people, rendering them unproductive and making them prime clients of food relief. Furthermore, large areas in the savannah belt with adequate rainfall and high productivity, especially for foodgrains, are becoming increasingly inaccessible because of the war. This is a lost opportunity for the country to increase its total grain production and employment for the rural population and hence to reduce its vulnerability to food insecurity.

Participation of Rural Population

Insofar as policies affect rural areas directly, the stabilization of these areas in prevailing situations of discontinuity requires the active participation of the rural population. This participation should be a two-way process: on the one hand, decentralization of power from the center to local, provincial, and regional levels is called for, and on the other hand, rural people should form their own rural institutions that would identify their problems, propose solutions to these problems, and commit resources toward meeting the costs involved. Adoption of such policies would probably enhance stability even when the central government changes. Thus the rural people would have their interests safeguarded despite the volatility of the political system.

Stable rural institutions are of critical importance during food shortages and famine crises. If local relief and rehabilitation committees were already in existence, they could be mobilized quickly and would be of great assistance to the national institutions and foreign or domestic relief agencies in supplying information, identifying the needy, and distributing food.

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[9] The set of conclusions presented here also builds on insights gained from a policy workshop in Sudan, where the study findings were reviewed by leading policy analysts and policymakers. The workshop's findings are synthesized in Zaki, von Braun, and Teklu 1991.

Macroeconomic Policies

Macroeconomic policies should be geared toward establishing a sound environment where fiscal, monetary, trade, and exchange policies provide a framework for reducing drought-hunger relationships. Policies should be comprehensive and effective in dealing with structural problems and economic distortions in favor of efficient resource allocation and sustained economic growth. Control of inflation is crucial to economic and political stability.[10]

Specific Policy Priorities

Sustainable Growth in Traditional Rainfed Agriculture

The call for a broad-based strategy for development of rainfed agriculture, which was initiated in a government study (Sudan, Ministry of Finance and Economic Planning 1986), is central to a comprehensive famine-prevention strategy.

The government study defines the goals of rainfed agriculture: to promote production to meet regional self-sufficiency and national self-reliance; to enhance sustainable income and employment generation; and to conserve, rehabilitate, and improve natural resources. Justifications for the pursuit of regional self-sufficiency (particularly millet in the west) are based on recognition of current low levels of infrastructure and market connections. The study recognizes constraints imposed by low and variable unimodal rainfall, seasonal labor shortages, the shrinking productive land base and declining soil productivity, and existing low-input farm technology and managerial practices.

The present trends in traditional rainfed agriculture, with farmers resorting to more subsistence farming, need to be reversed. The rural economy needs to move toward monetization by improving farmgate prices of all crops, whether foodgrains or cash crops, by opening up produce and input markets, and by improving rural financial markets.

Rural Infrastructure

Available evidence reveals a low level of infrastructural development in Sudan, especially in the west. Infrastructure development is a critical component in the promotion of a stable and sustainable rainfed agriculture. Reduction in the cost of transportation provides improved opportunity for mobility of goods and people. It facilitates expansion of market outlets, enhances market integration, and reduces the probability of market failure. Expansion of the transport network also facilitates improved access to social overhead services (such as health, education, potable water), which contributes to improved productivity and, consequently, to increased income-generation capacity and improved nutritional status. Experience from other countries also indicates the positive linkage effect of infrastructure development on expansion of rural services and diversification of the rural economy (IFPRI 1988). Thus, expansion of infrastructure has potentially great short- and long-term benefits to Sudan.

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[10] A comprehensive discussion of these issues and their links to famine is presented in Atabani 1991 and is therefore not expanded here.

Public Works Programs

The provision of road infrastructure (in addition to water supply, reforestation, and so forth) should occupy a central place in public works schemes. It must be positioned where it has a great impact on providing a critical and catalytic link in the development process. Under present cost constraints, this may mean giving priority to areas of high agricultural potential. To promote employment and a steady flow of income, the emphasis should be on labor-intensive techniques that are tailored to the employment needs of the rural population. Such synchronization of provision of work with the employment needs of those who seek employment (wage rates presumably are set to attract the most needy) has the added advantage of creating incentives to shift away from current employment practices with adverse environmental effects (for example, cutting trees to make firewood and charcoal). Such a practice of providing employment to the food-insecure to create infrastructural assets could also be expanded in times of crisis to generate relief employment to protect income and asset bases.

The main cost component in such infrastructure and employment-generating schemes is payment for labor. Since the majority of the participants would come from low-income families, they are expected to spend a large share of income on food. Food payments as wage components can play a role, since, given the current development of market infrastructure, market transaction costs to obtain food at the marketplace are high. Food wages provide a more effective utilization of food aid for development undertakings. This observation is derived from Sudan's experience in the 1980s, when, despite much-expanded food aid, little was used for development projects.

Government policies need to be directed toward the eradication of absolute rural poverty, which is the root cause of food insecurity. In addition to the economic policies outlined above, special attention to areas frequently visited by drought is required. Special employment and rural works programs that would enhance rural incomes, reduce vulnerability to food shortages, improve the efficiency of relief and rescue operations in case of need, and reduce environmental hazards should be given top priority. Sudan already has some experience in such programs, such as the International Labor Organization's labor-intensive project in White Nile Province, where a rural work program helped with construction of rural feeder roads, water supply, afforestation, and the like, and the Gum Arabic Restocking Project, with headquarters in El Obeid, that exchanges food and basic necessities for the commitment of rural people's land to be restocked with gum arabic and worked with their family labor. In all of these efforts, replicability should be an essential feature and measure of success.

Supply of Inputs

Traditional farming is spread over a vast area and in some cases may be located hundreds of kilometers from input markets. The government may have to ensure adequate and timely availability of these inputs at prices that farmers can afford. Farm-input prices need not be heavily subsidized, but policy can affect prices by reducing transaction costs. But because of the vast farming area, the government capability may be neither adequate nor most efficient in making these inputs readily available; hence, there is room for the private sector to undertake a significant role in the acquisition and distribution of farm inputs. In case the private sector takes an active role in the farm-input trade, one of the measures that the government can undertake to reduce transaction costs is the supplying of credit to the farmers for input purchases.

Adaptive Research, Technological Packages, and Extension

There is an urgent need to bolster adaptive research efforts and to develop, adopt, and continuously disseminate technologies based on existing knowledge and practices that would enhance productivity, increase incomes, augment limited inputs (land and water in particular), reduce production variability due to low and variable rainfall patterns, promote conservation of soil fertility, and curb environmental degradation.

The emphasis should be on technological change to assist in reversing the process of declining agricultural productivity. In the context of Sudan's low-resource and drought-prone areas, such a role entails the generation of technological capacity to deal with low and variable rainfall, low soil fertility, seasonal shortages of labor, and farmers' management practices. The bases of such a process lie in improving the agronomic environment with existing technologies. Such technologies involve improvement in the structure, fertility, and water-holding capacity of existing poor soils, particularly sandy soils in the arid regions, and increased availability of water. However, technologies that focus on the existing knowledge base of resource conservation have a limited capacity to achieve rapid agricultural growth (Staatz 1986). It is imperative to move to high-input technology that uses greater proportions of purchased inputs and fits into both the arid tropical environment and farmers' production-income-consumption strategies. But available on-shelf technologies that are adapted or developed for the African environment are limited at present (Matlon and Spenser 1984; Stoop et al. 1982). The strategy should, therefore, realize the great challenge ahead and call for promotion of research and development to ensure a sustained and viable development process.

The Jebel Marra experience in Darfur in 1984-85 also establishes a strong case for increased access to agricultural technology, at least in high potential areas as a start. Families with access to irrigation and improved production technology, such as improved plows, have demonstrated a greater capacity to buffer periodic food crises. This capacity has been enhanced through improvement in their level of food production, income, and asset base. Moreover, in time of crisis, these areas have greater capacities to transfer food or to provide employment for temporarily distressed migrants.

In the area of water conservation, attempts should be made to improve dry-farming techniques and to introduce contour cultivation and drip irrigation. Water-harvesting techniques, such as small dams in watershed areas like Jebel Marra and heavy plowing of hard-crust *Nagaa* soils (caused by deposition of silt in water-course deltas), seem ready for wider application. Recently, some serious steps were undertaken to expand tubewell irrigation in Northern Kordofan basins that has provided opportunities for perennial production of high-value crops like citrus and vegetables, increasing incomes from agriculture and expanding employment.

The development of technological packages in research centers is necessary but not sufficient. Sufficiency would be partially met by the provision of efficient agricultural extension services that would deliver these packages to the farmers in good time and in acceptable forms. Such services are yet to be developed for Sudanese agriculture or, in particular, for the traditional rainfed subsector. Apart from the extension services provided by the Jebel Marra Rural Development Project, there is hardly any extension service in operation in the traditional areas. After the establishment of the adaptive research facility in western Sudan, serious efforts should be undertaken toward development of extension services that would disseminate the technology packages to farmers.

Protection of the Environment in Drought-Prone Areas

Preserving, promoting, and protecting the environment is fundamental to enhancing the future productive capacity of the drought-prone areas. Creeping desertification and climatic change, increasing human and livestock population, impoverishment of the rural population, and past policy failures (most notably the rapid expansion of large-scale mechanization into marginal and fragile areas, and the choice of spatial distribution of water points in the arid and semi-arid zones) have contributed to the degradation of the environment. It is essential that a strategy for protecting the environment should call for policies that would modify the existing common property rights system, provide incentives for voluntary resettlement of the rural population, and align farmers' time preferences with society's preferences by providing income support in times of stress. The latter measure is imperative for slowing down rapid deforestation and encouraging the rural population to participate in protecting the environment.

Emergency Preparedness and Relief

The basic concept of famine preparedness entails a public commitment to intervene effectively in time; to build institutional capacity at national, regional, and local levels; to detect and diagnose indicators of distress; to prepare programs and projects on a continuous basis; and to execute development and relief undertakings in times of revealed needs. Such actions will increase the preparedness of Sudan to meet emergency situations of localized or nationwide food shortages and famines.

Buffer Stocks for Price Stabilization

Central to these actions is the development and efficient operation of a buffer stock that would be located at storage facilities close to high-risk areas. The stocking and the dissemination of grains require clear guidelines as to the eligible groups, the period at which distribution commences, the price of grains for each category within the eligible group, and the payment mode, whether in cash or in kind, of public works.

No comprehensive data exist on the extent of stock-building in Sudan, particularly in the private sector. The public stockholding policy was initiated in the mid-1960s with the authorization of the Agricultural Bank of Sudan (ABS) to maintain cereal buffer stocks, to stabilize support prices, and to make grain available in times of food shortage. The annual average size of ABS stock never exceeded 10 percent of total cereal production in any season until 1984/85, owing to financial and storage constraints (Abdel Nour 1988). The delayed and limited role of the government in providing relief food in 1984/85 was related to the lack of both adequate food reserves and capacity to import. ABS stockpiling, however, was greatly expanded in the aftermath of the 1984-85 famine. Issues that are likely to loom in the future are determination of "optimum size," procurement and release prices, and the extent of involvement in foreign trade for price stabilization.

Relief-Management and Early-Warning Systems

Relief management entails establishment by the government of a high-powered system with a network extending to local, provincial, regional, and national levels. The objective of such a relief system should be not only the supply and distribution of food during shortages and famines, but also the prevention of famine in the first place. Thus the relief institutions should establish a well-equipped (both in terms of equipment and professional personnel who are highly motivated) early-warning system with strong links to local governments and communities.

Strengthening Rural Health and Sanitation

A strong rural health system is a necessity under any circumstances and not just from a famine-prevention perspective. The strong linkages between infrastructure and health and sanitation in rural areas have been highlighted in this research. The strengthening of rural health services is a key function of public investment for human resource development. Not only does improved hygiene directly affect child nutrition, it facilitates coping with drought-related consumption fluctuations. A strengthened health-service system can be a powerful tool for managing relief more effectively. Therefore, the quality of health services and the density of the network in rural areas need to improve. Community participation and resources should not be underestimated in molding an effective rural health system. The rural poor appreciate the role of health services for survival and are willing to commit resources. An effective, active system deals with the symptoms of chronic food insecurity and thereby strengthens the capacity of the poor to survive transitory food insecurity and the related health risks.

Legislation for Famine Prevention

For the relief institutions to operate efficiently, there is a need, first, to design a well-structured relief legislation that would incorporate the basic relief policies to which the government is fully committed. Second, in addition to promotion of production and infrastructure bases, public policies should be concerned with bridging any shortfalls in domestic production to meet food demands. Third, dependence on food aid should be minimized, since factors other than humanitarian considerations (such as world market situation and political leverage) play important roles in its allocation. Hence, it is necessary to maintain adequate buffer stocks or enhance the capacity to import or both. In the case of Sudan, policies of stockholding and foreign trade have become more important because of increased production shortfalls. Fourth, in the short term, relief policies should include special programs for the most vulnerable segments of the population. Feeding programs for children, infants, and their mothers to dissipate hunger and malnutrition, and medical assistance to reduce the incidence of diarrhea and other epidemics, would strengthen these weak groups and improve their chances of survival in the face of food shortages.

The relief legislation should detail the responsibilities of the national and regional governments and the local authorities in identifying and declaring areas of food shortages and famines and dissipating the impacts of these shortages and famines. Each vulnerable locality should be obliged to maintain a certain amount of grain in storage in accordance with a timetable drawn up on the basis of monthly requirements, with a declining balance as the agricultural production season advances and a buildup in the same manner. The authorities at the local level would be required to prepare periodically (weekly and monthly) a report that would include detailed statistics and information on production, stocks, withdrawals, and the number of people likely to be subject to malnutrition or starvation. The early-warning system would, in addition to other information on rains and the like, compile these data at the provincial and regional levels, analyze them, and present a full report to the regional and central authorities with recommendations for specific actions authorized by the legislation. The central authorities would make public announcements about the situation and seek assistance, if necessary, from the international community. Authorities, especially at the local level, would then be entrusted with the field inspection of the relief work and assessment of the effectiveness of the relief program.

Linkages between Relief and Rehabilitation

Relief and rehabilitation are integral to the development process. In the context of drought-prone areas, where income levels are low and variable and famines are recurrent, it is imperative to devise a strategy for protecting the development process from going off track. Rehabilitation should be integrated into such a process to ensure that no time is lost in getting back to the development process. Sustenance of life in periods of emergency, and interventions to rehabilitate environmental, community, and household assets and to enhance and protect household incomes fall in the realm of development process. The critical link between relief/rehabilitation and development lies in the choice of programs and projects toward these ends. Information on the relative impact of these programs and projects on sustained growth in food supply, employment and income, on moderation of variation in production and income, and on protection of assets is vital for selection of the optimal policy mix. This information represents an important area that future research work should focus on in order to provide an empirical base to assist policymakers in choosing efficient and effective projects that are optimal for an integrated relief-rehabilitation-development framework.

APPENDIX

The Relief and Rehabilitation Commission

The responses to the 1984-85 famine represent a great deal of regression from the concepts and procedures embodied in the 1920 famine regulations. The key omissions were a public policy initiative to detect and respond to famines, establishment of administrative institutions, and the linkage of relief to development. The de-linking of relief from development has been, in fact, a typical feature of the whole development approach since independence. The future lies in combining these components and developing a flexible and efficient system of response to a famine threat. The establishment of the Relief and Rehabilitation Commission (RRC) represents a step in the right direction.

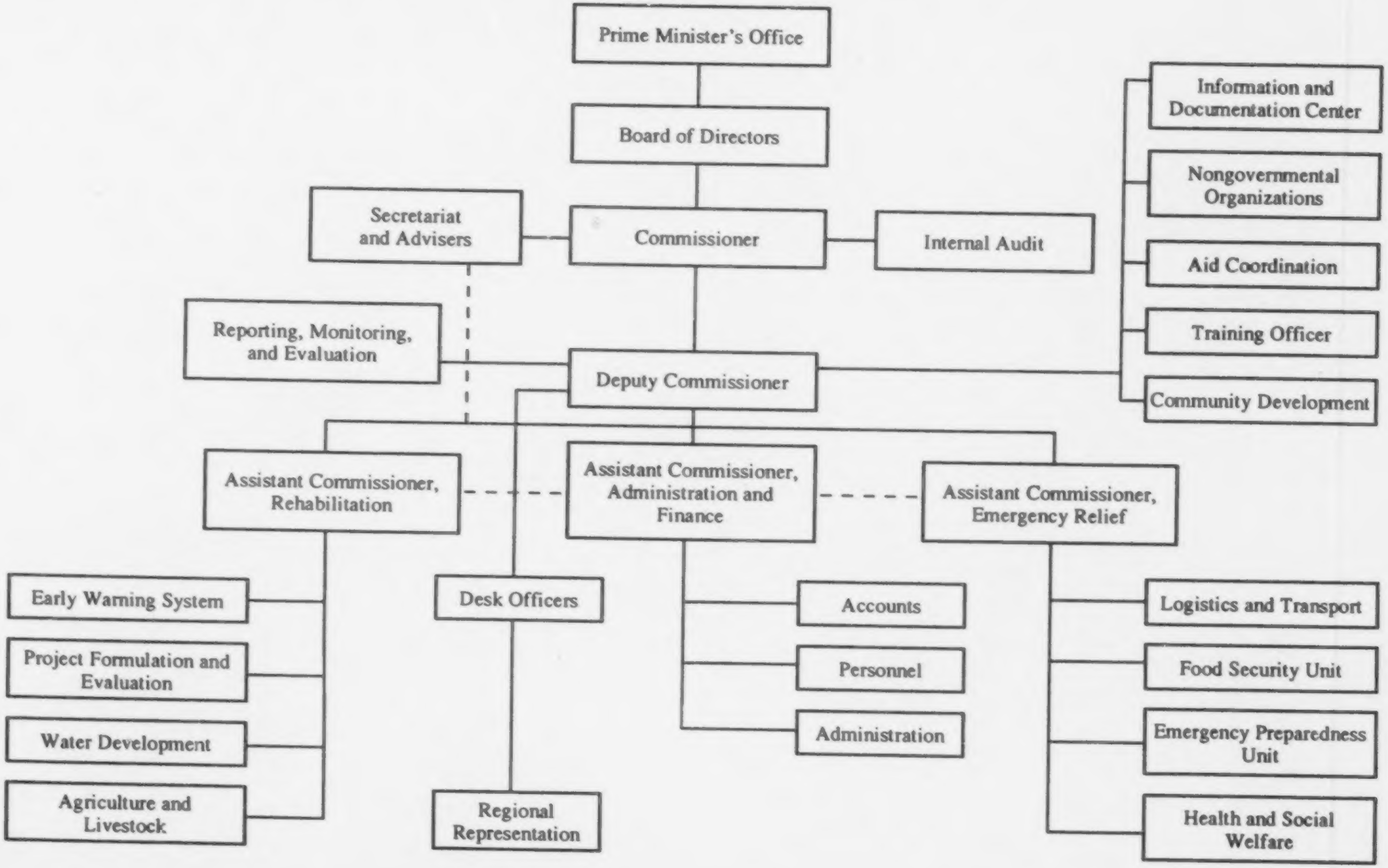
This commission was established in May 1985. It is an independent corporation directly under the prime minister, with a board of directors and a ministerial commissioner (Figure 15). Article 4 of the RRC Act states that "the objectives of the Commission are to draw and implement policies, plans, and programs for mitigating the effects of and rehabilitating areas affected by catastrophes, drought, desertification, and degraded environmental orders, and to mobilize the necessary international and local resources." The duties of the RRC are carried out in close coordination and cooperation with the Ministry of Finance and Economic Planning, which is the central government authority responsible for the country's socioeconomic development planning and budgeting.

The early-warning surveillance unit has been incorporated in the RRC since March 1986. There are some similar units already operating in some of the technical ministries and autonomous organizations, such as the Ministry of Agriculture and Natural Resources, Ministry of Health and Social Welfare, and the Meteorology Department in the Ministry of Defense. The early-warning unit of the RRC does not collect data and, therefore, does not duplicate the data-gathering activities of the technical ministries. It uses the data collected by these ministries to yield indications about the approach of problematic situations.

The government Act relating to regulations for the work of NGOs in the country was passed by the constitutional assembly only in early 1988. The Ministry of Health and Social Welfare was authorized to register the NGOs. However, the RRC still plays an important role in the coordination and technical supervision of their work in the Sudan. This role requires a special unit in the RRC to monitor and supervise the NGOs involved in relief and rehabilitation. This unit keeps appropriate records on the credit potentials of the organizations and their sources of funding.

The authority of the RRC Commissioner is delegated to the governor of each region. At the same time, all governors are members of the board of directors of the RRC. Each region has a regional relief committee headed by the governor, who may delegate this authority to one of his or her senior officials. In this manner, the connection between the RRC and all regions of the country is realized.

Figure 15—Structure of the Relief and Rehabilitation Commission in 1988


Prime Minister's Office
Board of Directors
Secretariat and Advisers
Commissioner
Internal Audit
Information and Documentation Center
Nongovernmental Organizations
Aid Coordination
Training Officer
Community Development
Reporting, Monitoring, and Evaluation
Deputy Commissioner
Assistant Commissioner, Rehabilitation
Assistant Commissioner, Administration and Finance
Assistant Commissioner, Emergency Relief
Early Warning System
Project Formulation and Evaluation
Water Development
Agriculture and Livestock
Desk Officers
Regional Representation
Accounts
Personnel
Administration
Logistics and Transport
Food Security Unit
Emergency Preparedness Unit
Health and Social Welfare

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GROWTH IN JAPAN'S HORTICULTURAL TRADE WITH DEVELOPING COUNTRIES: AN ECONOMIC ANALYSIS OF THE MARKET

Masayoshi Honma

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Masayoshi Honma

Research Report 89
International Food Policy Research Institute

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Library of Congress Cataloging-in-Publication Data

Honma, Masayoshi, 1951-
Growth in Japan's horticultural trade with developing countries : an economic analysis of the market / Masayoshi Honma.
p. cm. — (Research report / International Food Policy Research Institute ; 89)
Includes bibliographical references.
ISBN 0-89629-092-1
1. Horticultural products industry—Japan. 2. Horticultural products industry—Developing countries. I. Title. II. Series: Research report (International Food Policy Research Institute) ; 89.

HD9016.J42H63 1991 91-43549
382'.415'0952—dc20 CIP

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FOREWORD

As the affluent populations in developed countries become more cosmopolitan as a result of technological advances in transportation and communications, their desire for exotic goods stimulates demand for nontraditional imports. This trend is particularly evident in fruits, vegetables, and cut flowers, and nowhere more so than in Japan. Noting that developed-country imports of horticultural products have increased steadily over the past decade, developing countries are increasingly adopting policies to encourage production of new varieties for export.

The need is great for developing countries to find nontraditional exports at a time when growth in the traditional ones is foundering. However, the pitfalls are many, and little research exists to provide guidance. In 1990, IFPRI published the first comprehensive analysis of world trade in horticultural products, *Horticultural Exports of Developing Countries: Past Performances, Future Prospects, and Policy Issues,* Research Report 80. That report placed high priority on the need for detailed country studies, especially of the major markets, that can guide developing countries in devising appropriate strategies for expanding their horticultural sectors. This study on Japan was undertaken in response to that call. It not only provides a wealth of useful data on the products and the exporting countries now competing in Japan, it also presents a broad overview of the structure of the Japanese market and the problems inherent in it.

Among the principal findings from the analysis, the importance of price changes in explaining supply shifts from one exporter to another indicates that Japan's horticultural imports are subject to significant price competition. Developing-country exporters are also concerned about Japan's phytosanitary regulations, the behavior of large traders, and the low efficiency of domestic distribution.

Just Faaland

Washington, D.C.
December 1991

ACKNOWLEDGMENTS

I am grateful to the International Food Policy Research Institute (IFPRI) for providing the opportunity for me to do research at IFPRI for two years as a visiting research fellow. During that time, I benefited from the comments and suggestions of many colleagues at IFPRI, in particular Nurul Islam, Alberto Valdés, Leonardo Paulino, and Romeo Bautista. My thanks are extended to Suthad Setboonsarng in Thailand, Min-Tze Wu in Taiwan, Audie Ugalino in the Philippines, and Ryuzo Koyama in Japan, who provided kind assistance and made arrangements for data collection and information gathering in each area. I am also indebted to Elizabeth Jacinto, my research assistant at IFPRI, who aided me in data processing at various stages of research. Last but not least, I would like to express my thanks to Yujiro Hayami for encouraging and stimulating me throughout the period of this research.

Masayoshi Honma

1

SUMMARY

International trade in horticultural commodities such as cut flowers, vegetables, and fruits is expanding at a higher rate than trade in other agricultural commodities. Although both demand and supply in current horticultural trade is dominated by developed countries, the rapid growth in international markets attracts many developing countries' attention because future expansion of agricultural exports from developing countries seems to lie in that direction. Because horticultural production is generally labor-intensive, developing countries with abundant labor relative to capital and land have a comparative advantage in horticulture.

This study explores the possibilities and opportunities for expansion of horticultural exports from developing countries to a rapidly growing single market—Japan. Japan increased its horticultural imports by 12.5 percent annually in value during the 1980s, while its growth rate for total agricultural imports stayed at 5.2 percent annually. Japan is now the fifth largest importer of fruits and vegetables in the world; it accounted for 7.1 percent of total imports of fruits and vegetables by all the market economies on average during the three-year period, 1986-88. Developing countries supplied 39 percent of Japan's total imports of horticultural commodities in value in 1988, compared with 47 percent in 1980. The developing countries' share was reduced because they could not compete with rapid increases in exports of vegetables, particularly processed vegetables, from developed countries to Japan. However, developing countries were well able to cope with competition from other exporters of fruit to Japan.

Japan is not only increasing the volume of its horticultural imports, it is also expanding the range of commodities imported. But trade statistics are not disaggregated enough to cover most new commodities in detail. For this study, 14 commodities were selected for analysis, with emphasis on imports from developing countries: cut flowers, onions, green beans, dried and canned bamboo shoots, pickled and nonpickled ginger, bananas, mangoes, avocados, kiwifruit, and fresh, frozen, and canned pineapple. These 14 commodities accounted for about 30 percent of the total value of horticultural products imported by Japan on average in 1987-89. Major suppliers of these commodities to Japan are mainland China, Mexico, the Netherlands, New Zealand, the Philippines, Taiwan, Thailand, and the United States. A look at Japan's market shows that imports of the same commodity may perform differently in both quantity and price, depending on their source of supply. Horticultural products are characterized by diversity of varieties and variability of production seasons in supplying countries. Therefore, it is natural to distinguish horticultural imports not only by commodity but also by source of supply.

Investigation of Japan's horticultural import behavior is based on a two-stage budgeting procedure. In the first stage, expenditure on imports of a commodity—

mango, for example—is determined. In the second stage, expenditure is allocated among individual import products from different countries, say, mangoes from the Philippines and Mexico. Based on this theory of product differentiation, the characteristics of Japan's horticultural import demand are captured by estimating two types of import demand equations: the first-stage import demand equations, which represent total demand for imports of a commodity, and the second-stage trade-flow equations, which are expressed as a function of individual import prices received by each supplier of the commodity and the total import expenditure on all imports of that commodity.

The empirical estimations of the first-stage import demand equations show great sensitivity to changes in prices of imports of cut flowers, nonpickled ginger, mangoes, avocados, and kiwifruit. Canned bamboo shoots, bananas, and fresh pineapple were also fairly price sensitive. Income elasticities, which represent the sensitivity of imports to Japan's income changes, were significant for imports of cut flowers, canned bamboo shoots, pickled ginger, mangoes, and canned pineapple. It appears that most of the horticultural commodities included in this study are more sensitive to price and income changes than are other agricultural commodities.

The import demand characteristics of a commodity, however, are not shared equally by all the trade flows of that commodity. Most trade flows resulted in significant own-price coefficients in the estimation of second-stage trade-flow equations, but the degree of sensitivity to price changes differs from one trade flow to another. It is natural to expect varying degrees of sensitivity because each country provides different varieties of the commodity, which do not substitute perfectly for products from other suppliers. Even the commodities whose price elasticities are relatively small—some vegetables, for example—show great sensitivity to price changes in trade flows. This means that Japan's consumers and traders are seeking cheaper products, so that price competition among foreign suppliers is inevitable.

Japan's preferences for imports by source of supply, given relative prices, are captured by estimating coefficients of the import expenditure variable in trade-flow equations. Statistically, 13 trade flows out of a total of 31 have been favored with market growth; their shares tend to increase even when there is no change in relative prices, as Japan's total imports of the commodity increase. On the other hand, there are 6 trade flows that statistically appear to be losing market share as Japan's horticultural imports grow.

The estimation results of the first-stage import demand and the second-stage trade-flow equations are combined to obtain the total effects of price and income changes on trade flows. The calculated own-price and income elasticities by trade flow provide useful information to help exporting countries decide on appropriate strategies for expanding their horticultural exports to Japan. The study shows that for 20 trade flows out of a total of 31, exporting countries could increase not only the quantity they export but also export earnings if they could reduce their prices by reducing the costs of production, marketing, and distribution.

The calculated income elasticities of individual trade flows are divided into two groups, one group having a very large average income elasticity and the other a very low one. Some trade flows resulted in a low income elasticity even though they are part of a family of commodities with large income elasticities because the coefficient of the import expenditure variable is small in the trade-flow equations.

Based on elasticities calculated for trade flows, the contribution of each variable to changes in annual import growth rates by trade flow are determined. For many exporting countries, changes in their own prices were the major reason for changes in growth in Japan's market. Changes in competitors' prices also explained the growth in some trade flows. The importance of price changes in explaining shifts from one exporter to another indicate that Japan's horticultural imports are subject to severe price competition.

However, nonprice competition also plays an important role in growth in Japan's market. For example, sales promotions by exporters have had significant effects on exports of cut flowers from the Netherlands and bananas and mangoes from the Philippines. In addition, the Netherlands has benefited from preshipment inspection of cut flowers, which reduces the risk of rejection due to quarantine regulations on arrival at Japan's ports. The market structure is also important for understanding the growth of horticultural imports. If the market is not completely open to competition, the pricing mechanism is affected by the behavior of large traders and so is the import quantity.

Import growth of horticultural commodities is also subject to Japanese policy. Exporting countries are particularly concerned about Japan's phytosanitary regulations. Although it is difficult to separate unnecessary restrictions from necessary ones, the system of restrictions and its background should be examined carefully. Some complaints by exporting countries are directed at the operation of regulations rather than at the regulations themselves because the number of inspectors has not proportionally increased relative to the increases in horticultural imports, which has resulted in delay and congestion in inspections and custom clearances.

The efficiency of domestic distribution in Japan is also a concern. Distribution costs for vegetables and fruits account for 50-70 percent of retail prices in Japan. To judge Japan's distribution efficiency, this figure should be compared with other countries' data, but it seems possible to reduce costs by integrating distribution. Retail costs for vegetable and fruit sales in supermarkets are 20 percent less than those in small shops. According to an evaluation of assumed policy changes in Japan, if the Large Retail Store Law, which regulates the opening of major retail operations, were abolished, and through competition, all the retail shops could make their sales operations as efficient as the supermarkets, it would cause a more than 10 percent increase in imports of some commodity flows.

The importance of distribution costs is emphasized in international price linkages, too. In an examination of import prices in Japan and corresponding export prices in exporting countries for 16 trade flows, international transportation costs and margins are found to vary widely, and in some trade flows, the international distribution costs account for 70 percent of the import price. It also appears that export price changes and exchange rate changes are not fully transmitted to import price changes in international distribution.

Finally, supplyside conditions are examined, using a linearly homogeneous production function, to see what determines export prices. Export price changes in this framework are a function of wage rate and capital rental changes weighted by cost shares. The residuals in export price changes are interpreted as the effects of technological progress. Export price examinations indicate that high labor costs exert pressure on most horticultural products in Taiwan and possibly improve efficiency in Thailand's production of some horticultural commodities.

In conclusion, this study finds that Japan's horticultural import growth has derived from both price and nonprice factors. However, it must be emphasized that further investigations of domestic and international distribution systems for horticultural products and the role of governments in both importing and exporting countries are necessary. To accomplish these goals, detailed statistics are needed.

2

OVERVIEW OF JAPAN'S HORTICULTURAL IMPORTS

International trade of horticultural products such as cut flowers, fruits, and vegetables is attracting much attention from agricultural trade researchers because of its rapid expansion in recent years. This expansion of horticultural trade is related to several factors. One is the change in food consumption patterns brought about by a rise in health consciousness; consumers, especially in developed countries, are avoiding high-calorie, high-cholesterol foods. Vegetables and fruits play an important role in this changing dietary pattern. Other factors are the remarkable technological improvements in transportation and the increased availability of air transport. These developments in transportation make it possible to ship perishable products internationally at lower costs. Also, the increase in the number of international travelers contributes to the growth in horticultural trade because eating experiences abroad help stimulate demand for new fruits and vegetables at home.

Many developing countries are interested in expanding horticultural trade, which could contribute to agricultural diversification, employment opportunity, and foreign exchange earnings in developing countries. Developing countries with abundant labor relative to capital and land are believed to have a comparative advantage in horticultural products, which are generally labor-intensive.

Despite the increasing importance of horticultural trade in the world market, the research results in this sector are limited. In the literature, several studies exist that examine production and potential exports of horticultural commodities in developing countries. The Institute for Horticultural Economics in Germany conducted studies on export-oriented horticulture in some African countries (Hörmann and Wietor 1980; Hörmann 1981; Hörmann and Will 1987). The U.S. Agency for International Development examined horticultural exports in El Salvador, Jamaica, and Kenya (Daines and Hargreaves 1985; Buckley 1986; Jaffee 1986). And IFPRI investigated the effects of nontraditional horticultural exports on a rural economy in Guatemala (von Braun, Hotchkiss, and Immink 1989).

Trade studies on horticultural commodities are mostly related to regional competitiveness in horticultural products. For example, the U.S. Department of Agriculture conducted a study on the competition between Florida and Mexico for vegetable trade (Buckley et al. 1986), and several California study groups have examined the market conditions for exports of California specialty crops (Moulton et al. 1986; Stamoulis et al. 1989). Horticultural trade in Europe and Northern Africa was considered in the process of expanding the European Community to include Greece in 1981 and Spain and Portugal in 1986 because these countries have a comparative advantage in horticulture and would cause changes in horticultural trade patterns when they joined the European Community. Studies by Sarris

(1983) and the World Bank (Bale 1986) examine the effects of the expanded European Community on horticultural trade.

In terms of coverage of commodities and countries, the most comprehensive study of developing-country horticultural trade is provided in a recent IFPRI research report (Islam 1990). Islam suggests that detailed country studies are needed to help developing countries devise appropriate strategies for expanding their horticultural sectors. Following Islam's suggestion, this report focuses attention on the rapidly growing Japanese market. Japan's imports of horticultural products have been rapidly increasing. Japan is now the fifth largest importer of vegetables and fruits in the world market, following Germany, the United States, the United Kingdom, and France. During 1986-88, Japan accounted for 7.1 percent of total imports of vegetables and fruits by market economy countries (Table 1). This report aims to examine Japan's import behavior regarding horticultural products and to determine the sources of its import growth, with special emphasis on trade flows from developing countries. Before going into a detailed analysis of Japan's import behavior, it may be useful to start with an overview of the structure of Japan's horticultural imports.

Growth of Horticultural Imports

The import value of Japan's horticultural products in U.S. dollars increased by 16.3 percent a year during the 1970s, which was about the same growth rate as total agricultural imports (Table 2). This high growth rate stemmed from increases in

Table 1—Value of vegetables and fruits imported by five major importing countries from market economy countries, 1986-88 average

Country	Vegetables	Fruits	Total Horticultural Imports
		(US$ million)	
Germany, Federal	3,396	4,035	7,431
Republic of	(20.9)	(17.8)	(19.1)
United States	1,497	3,566	5,063
	(9.2)	(15.7)	(13.0)
United Kingdom	1,530	2,247	3,777
	(9.4)	(9.9)	(9.7)
France	1,483	2,252	3,736
	(9.1)	(9.9)	(9.6)
Japan	1,009	1,753	2,762
	(6.2)	(7.7)	(7.1)
Total market	16,220	22,705	38,925
economy imports	(100.0)	(100.0)	(100.0)

Source: United Nations, *Yearbook of International Trade Statistics* (New York: UN, various years).

Notes: Imports from the centrally planned economies are not included. Figures in parentheses are percentages of the total imports of the market economies.

Table 2—Value and growth of horticultural products imported by Japan, 1970, 1980, and 1988

Imports	Import Value 1970	Import Value 1980	Import Value 1988	Growth Rate/Year 1970-80	Growth Rate/Year 1980-88
	(US$ million)			(percent)	
Cut flowers[a]	0.3 (0.0)	19 (0.1)	108 (0.4)	50.9	24.4
Vegetables[b]	72 (1.7)	548 (3.1)	1,484 (5.5)	22.5	13.3
Fruits[c]	237 (5.7)	838 (4.7)	2,004 (7.5)	13.5	11.5
Total horticultural	310 (7.5)	1,405 (7.9)	3,596 (13.4)	16.3	12.5
Total agricultural	4,144 (100.0)	17,811 (100.0)	26,805 (100.0)	15.7	5.2

Sources: United Nations, *Commodity Trade Statistics*. (New York: UN, various years); Food and Agriculture Organization of the United Nations, *FAO Trade Yearbook* (Rome: FAO, various years).

Note: Figures in parentheses are percentages of total agricultural imports.

[a] Includes foliage.

[b] Includes potatoes and pulses.

[c] Includes nuts, except oil nuts.

import quantity, as well as from price increases due to the first oil crisis and to the world food crisis in the mid-1970s. The growth in total agricultural imports in the 1970s, however, was mostly due to price increases.[1]

In the 1980s, the value of total agricultural import growth slowed to a 5.2 percent rate of annual increase, but horticultural imports continued to grow 12.5 percent a year (Table 2).[2] Therefore, the share of horticultural imports in total agricultural imports—7.9 percent in 1980—increased to 13.4 percent by 1988.

The rapid increase in horticultural imports also changed the role of foreign products in the total supply of horticultural products to Japanese consumers. Table 3 shows shares of imports of cut flowers, vegetables, and fruits in total supply. Cut-flower imports were negligible in 1970, but accounted for 5.1 percent of the value of total supply in 1988. Imported vegetables accounted for 7.2 percent in 1988, and imported fruits, which play the most important role in horticultural imports, accounted for 24 percent of the expenditure on fruits. On average, horticultural imports held an 11.6 percent share of the value of total supply in 1988. The ratio is increasing as Japan becomes more dependent on imports for the supply of horticultural products.

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[1] Import quantity indices of vegetables and fruits increased by 11.9 percent and 6.8 percent annually from 1970 to 1980, while the index of annual growth of the quantity of total agricultural imports stayed at 4.0 percent during the same period (JMAFF 1989a).

[2] Increases in the import quantity index for 1980-88 were at 8.2 percent and 7.0 percent annually for vegetables and fruits, respectively, while increases in the total agricultural import quantity recorded a 5.5 percent annual growth rate (JMAFF 1989a).

Table 3—Share of imports in the value of the total supply of horticultural products, Japan, 1970, 1980, and 1988

Imports	1970	1980	1988
		(percent)	
Cut flowers[a]	0.3	2.4	5.1
Vegetables[b]	2.9	5.3	7.2
Fruits[c]	17.7	21.6	24.0
Total horticultural	7.8	9.4	11.6
Total agricultural	24.2	28.2	24.5

Sources: United Nations, *Commodity Trade Statistics* (New York: UN, various years); Food and Agriculture Organization of the United Nations, *FAO Trade Yearbook* (Rome: FAO, various years); and Japan, Ministry of Agriculture, Forestry and Fisheries, *Statistical Appendix to the Agricultural White Paper* (Tokyo: JMAFF, 1989).

Note: Based on the ratio of the value of imports to the sum of the values of imports and domestic production.

[a] Includes foliage.

[b] Includes potatoes and pulses.

[c] Includes nuts, except oil nuts.

Japan imports horticultural products from a number of countries all around the world (Table 4). In 1980 developing countries supplied 47 percent of Japan's total horticultural imports, but their annual growth rate was 9.8 percent, which was below the market growth rate of 12.5 percent, causing the development countries' market share to fall to 39 percent by 1988. Among developing countries, Asian countries are the most important, accounting for one-third of Japan's total horticultural imports in 1988. It is noteworthy, however, that other developing-country regions have increased their importance in Japan's market, with a remarkably high

Table 4—Value and share of horticultural products imported by Japan, by region of supply, 1980 and 1988

Country Group	1980 Value	1980 Share	1988 Value	1988 Share	Growth Rate/Year
	(US$ million)	(percent)	(US$ million)	(percent)	(percent)
Developing countries	663	47.2	1,402	39.0	9.8
Asia[a]	640	45.5	1,222	34.0	8.4
Latin America	15	1.1	119	3.3	29.2
Others	8	0.6	61	1.7	28.5
Developed countries	574	40.8	1,558	43.3	13.3
United States	452	32.1	1,103	30.7	11.8
Others	123	8.7	455	12.7	17.8
Centrally-planned economies	168	12.0	635	17.7	18.1
China[a]	147	10.5	595	16.5	19.0
Others	21	1.5	40	1.1	8.6
Total	1,405	100.0	3,596	100.0	12.5

Source: United Nations, *Commodity Trade Statistics* (New York: UN, various years).

Note: Horticultural imports include cut flowers and foliage, vegetables, fruits, and nuts, excluding oil nuts.

[a] Taiwan is included in China, not in Asia.

annual growth rate of 29.2 percent for Latin American countries and 28.5 percent for other developing countries during the period 1980-88. But developing-country regions other than Asia accounted for only 5 percent of Japan's total horticultural imports in 1988.

Developed countries supply more than 43 percent of Japan's horticultural imports, and the United States plays a dominant role as the most important single supplier, with a share of about 31 percent in Japan's market. However, other developed countries have recently emerged as significant suppliers of horticultural products to Japan, accounting for 13 percent of Japan's imports in 1988. Centrally planned economies, mainly China (including Taiwan), also supply substantial amounts of horticultural products to Japan—18 percent—and their growth rate is higher than average.

In order to examine the performance of developing countries in detail, Tables 5 and 6 provide data on the value and quantity of Japan's horticultural imports by commodity group, comparing developing countries with others in 1980 and 1988. Developing countries were competitive in both fresh and processed fruits, and their growth rates in value were comparable to others in these two commodity groups. However, developing countries were far behind in cut flowers and vegetables. There was a particularly large difference between developing countries and other countries in processed vegetables during 1980-88; whereas the annual growth rate for other countries was 26 percent, that of developing countries stayed at 8.3 percent. This resulted in a sharp decline of developing countries' share in processed

Table 5—Value and share of horticultural products imported by Japan from developing countries, by commodity group, 1980 and 1988

Imports/ Country Group	1980		1988		Growth Rate/Year
	Value	Share	Value	Share	
	(US$100,000)	(percent)	(US$100,000)	(percent)	(percent)
Cut flowers[a] from					
Developing countries	151	80	534	49	17.1
Others	38	20	550	51	39.6
Fresh vegetables[b] from					
Developing countries	1,868	50	3,130	38	6.7
Others	1,860	50	5,215	62	13.8
Processed vegetables[c] from					
Developing countries	1,040	59	1,971	30	8.3
Others	714	41	4,523	70	26.0
Fresh fruits[d] from					
Developing countries	2,592	40	6,150	40	11.4
Others	3,853	60	9,350	60	11.7
Processed fruits[e] from					
Developing countries	980	51	2,241	49	10.9
Others	958	49	2,296	51	11.5

Source: United Nations, *Commodity Trade Statistics* (New York: UN, various years).

[a] Includes foliage.

[b] Includes dried and shelled legumes and frozen or provisionally preserved vegetables.

[c] Prepared or preserved vegetables.

[d] Includes nuts, except oil nuts.

[e] Prepared or preserved fruits.

Table 6—Quantity and share of horticultural products imported by Japan from developing countries, by commodity group, 1980 and 1988

Imports/ Country Group	1980		1988		Growth Rate/Year
	Quantity	Share	Quantity	Share	
	(100,000 metric tons)	(percent)	(100,000 metric tons)	(percent)	(percent)
Cut flowers[a] from					
Developing countries	40	90	99	72	11.9
Others	4	10	39	28	32.2
Fresh vegetables[b] from					
Developing countries	2,533	48	4,199	44	6.5
Others	2,724	52	5,391	56	8.9
Processed vegetables[c] from					
Developing countries	1,028	62	1,219	25	2.2
Others	638	38	3,622	75	24.2
Fresh fruits[d] from					
Developing countries	8,429	68	9,297	58	1.2
Others	3,885	32	6,769	42	7.2
Processed fruits[e] from					
Developing countries	711	49	1,227	44	7.1
Others	732	51	1,553	56	9.9

Source: United Nations, *Commodity Trade Statistics* (New York: UN, various years).

[a] Includes foliage.

[b] Includes dried and shelled legumes and frozen or provisionally preserved vegetables.

[c] Prepared or preserved vegetables.

[d] Includes nuts, except oil nuts.

[e] Prepared or preserved fruits.

vegetables from 59 percent in 1980 to 30 percent in 1988. There was also a big difference in the growth rate of cut-flower imports from developing countries and others, reflecting a rapid increase in participation of others in Japan's market. The overall horticultural import growth rate for developing countries—9.8 percent per year for 1980-88—was much higher than the import growth rate of other agricultural products, but lower than the growth rate of horticultural imports from other countries, as a result of the decline in processed vegetable imports.

During the same period, there was a significant difference between developing countries and others in the growth rate of the quantity of fresh fruit imports (Table 6), despite the similarity in the value growth rate. The differences between growth rates of value and quantity are attributed to price changes and changes in the commodity composition of imports. In other words, high value growth indicates that Japan is increasingly importing more expensive fresh fruits from developing countries. In contrast, the growth rate for quantity of fresh vegetable imports from developing countries is about the same as the value growth rate, meaning that developing countries are exporting less expensive fresh vegetables to Japan, while other countries are shifting to exports of more expensive fresh vegetables.

Commodities in Horticultural Imports

What types of horticultural commodities are imported by Japan? Japan's imports of horticultural commodities may be classified into four categories according to the role they play in the Japanese market. The first group includes commodities that are imported when domestic produce is in short supply or out of season. The role of imports in this category is to make the commodities available in all seasons, supplementing domestic production rather than conflicting with it. Onions, for example, have traditionally been imported in this manner. Pumpkins and asparagus are imported in winter when little domestic produce is marketed.

The second category of horticultural imports includes commodities that are seldom produced domestically. Because there is no conflict with domestic products, imports of commodities in this group were liberalized soon after World War II. Most tropical fruits and specialties like nuts are included in this group.

The third group is the commodities to be processed, especially pickled vegetables. Imports of commodities in this group are preserved, at least provisionally, in brine, in sulphur water, or in other preservative solutions, which avoids problems with Japan's plant regulations and makes the supply relatively stable. There is a steady demand in Japan for pickled vegetables, but domestic products have been replaced with much cheaper imports, as homemade pickles became less common and most pickles are processed in factories. Examples in this group are ginger, cucumber, eggplant, and bracken.

The fourth group consists of all the rest of the imported horticultural products, which are characterized by rapid increases in demand. Most fruits and vegetables in this group were introduced relatively recently. This reflects the internationalization of Japan's eating habits, as a result of notable increases in overseas travel and wider information from abroad through mass media. The dynamic increases in demand for new and nontraditional horticultural products from abroad have been supported by the strong Japanese currency, which appreciated from 239 yen (Y) to the U.S. dollar in 1985 to Y128 in 1988. Therefore, many products that used to be unprofitable to import are now on the traders' list of imports.

Among vegetable imports, onions used to be the most important vegetable, by weight, though imports of onions fluctuate from year to year (Table 7).[3] Recently, however, frozen potatoes have emerged as the number one single item, by weight, among vegetable imports. Most imported frozen potatoes are cooked French fries, which are served at fast-food and U.S.-style family restaurants in Japan. These businesses have shown incredible growth: in 1988 there were 3,303 fast-food outlets with sales of more than US$2.8 billion, and 1,485 family restaurants with sales of US$2.2 billion, compared with 1,039 fast-food outlets and 578 family restaurants in 1980 (USDA 1990a, 16). This increase in frozen potatoes, together with increases in other frozen cooked vegetables, contributed greatly to the rapid import growth rate of processed vegetables from other countries in Tables 5 and 6.

In Table 7, pumpkins, at 41.8 percent, and asparagus, at 35.9 percent, show remarkably high annual growth rates. As mentioned already, both commodities are imported in seasons when domestic production is out of season. Both commodities owe their success to increasing general demand for healthy foods, especially green

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[3] Annual data for onion imports in Table 7 are 72,819 tons in 1979, 76,977 tons in 1980, 205,056 tons in 1981, 35,475 tons in 1987, 112,443 tons in 1988, and 80,780 tons in 1989. In this report, all tons refer to metric tons.

Table 7—Quantity of horticultural products imported by Japan, by commodity, 1979-81 and 1987-89

Commodity	1979-81	1987-89	Growth Rate/Year	Major Suppliers
	(metric tons)		(percent)	
Cut flowers	2,627	10,311	18.6	Thailand, Netherlands, Taiwan
Selected vegetables				
Onions	118,284	76,233	-5.3	United States, New Zealand, Taiwan
Garlic	2,607	3,245	2.8	China, Argentina
Shallots	32	264	30.2	France
Matsutake	481	1,784	17.8	Korea (Republic of), China, Korea (Democratic People's Republic of)
Asparagus	901	10,488	35.9	United States, Mexico, Australia
Pumpkins	4,528	74,041	41.8	New Zealand, Mexico, Colombia
Green beans	48,439	52,703	1.1	Thailand
Bamboo shoots, dried	3,953	3,820	-0.4	China, Taiwan
Bamboo shoots, canned	32,165	74,690	11.1	China, Taiwan, Thailand
Ginger, nonpickled	1,967	4,483	10.9	China, Taiwan, Thailand
Ginger, pickled	31,014	46,249	5.1	Thailand, Taiwan
Pulses, frozen[a]	55,516	81,352	4.9	Taiwan, United States, China
Sweet corn, frozen	24,939	35,045	4.3	United States, New Zealand
Potatoes, frozen[b]	29,363	114,269	18.5	United States, Canada
Selected fresh fruits				
Bananas	741,360	769,657	0.5	Philippines, Taiwan, Ecuador
Pineapple	112,344	139,406	2.7	Philippines, Taiwan
Mangoes	1,288	5,622	20.2	Philippines, Mexico
Avocados	720	3,762	22.9	United States, Mexico
Oranges	66,982	122,381	7.8	United States
Lemons and limes	104,405	119,797	1.7	United States
Grapefruit	153,851	238,374	5.6	United States, Israel
Grapes	1,367	6,965	22.6	United States, Chile, Taiwan
Cherries	2,180	9,166	19.7	United States
Melons[c]	4,259	18,649	20.3	United States, Mexico, New Zealand
Berries	1,074	2,750	12.5	United States, New Zealand
Papaws	2,722	5,108	8.2	United States
Kiwifruit	8,100[d]	53,747	37.1	New Zealand, United States

Sources: Japan Tariff Association, *Japan Exports and Imports (Commodity by Country)* (Tokyo: JTA, various years); Japan Vegetable and Fruit Import Safety Promotion Association, *Statistical Data of Imported Vegetables and Fruits* (Tokyo: JVFISPA, 1990).

[a] Pulses include peas, cowpeas, kidney beans, and green soybeans.

[b] Includes cooked potatoes.

[c] Includes watermelons.

[d] 1981-83 average.

vegetables. For this reason, green asparagus has driven out white asparagus, which used to be dominant.

Among imported fruits, bananas are the most important commodity, with imports of 770,000 tons on average in 1987-89, (Table 7), followed by grapefruit (238,000 tons), pineapple (139,000 tons), oranges (122,000 tons), and lemons and limes (120,000 tons). From 1979-81 to 1987-89, kiwifruit recorded the highest annual growth rate—37 percent. Other commodities with high annual growth rates are avocados and grapes (23 percent), and mangoes, cherries, and melons (20 percent). The range of fruits imported is expanding as new fruits are introduced in Japan, but the major suppliers are limited to a handful of countries, including the United States and developing countries in the tropical zone.

Only the commodities that are identified in Japan's trade statistics based on customs clearance are listed in Table 7. Despite increases in the number of commodities included in Japan's trade statistics corresponding to the change from the Customs Cooperation Council Nomenclature (CCCN) classification to the Harmonized Commodity Description and Coding System (HS) classification in 1988, the commodity coverage is not enough to follow the new developments in Japan's horticultural imports. Some other fresh fruits and vegetables are listed in Table 8; these are taken from import quantity data collected by the Japan Vegetable and Fruit Import Safety Promotion Association. Litchis among the fruits and garlic sprouts, broccoli, and snow peas among the vegetables have increased dramatically. The association listed 64 fresh fruits and 163 fresh vegetables in 1989 that

Table 8—Major fresh fruits and vegetables imported by Japan but not classified in Japan's trade statistics, 1987, 1988, and 1989

Commodity	1987	1988	1989	Major Suppliers
		(metric tons)		
Fruits				
Limes	570	739	922	Mexico
Tangelos	91	111	200	New Zealand, United States
Watermelons	133	107	106	United States, Mexico, Republic of Korea
Hamigua melons	0	766	379	China
Pomegranates	1,046	597	456	United States, Iran
Persimmons	69	107	138	New Zealand
Durians	63	104	89	Thailand, Philippines
Litchis	961	1,149	1,485	Taiwan
Passion fruit	18	15	15	New Zealand, United States
Cherimoyas	51	60	56	United States
Vegetables				
Garlic sprouts	5,396	5,952	6,180	China, Republic of Korea
Leek	89	176	234	Australia, Belgium
Cabbages	1,316	3,433	2,519	Taiwan, Republic of Korea
Broccoli	347	2,207	5,361	United States, Taiwan
Red salad	122	158	252	Italy, New Zealand
Cauliflowers[a]	n.a.	756	697	United States, Taiwan
Mushrooms[a]	n.a.	1,075	1,013	Taiwan, Canada
Chicory[a]	n.a.	451	519	Belgium, Netherlands
Carrots	2,165	799	1,101	Taiwan, United States, Republic of Korea
Edible burdocks	167	260	832	Taiwan
Edible lotus roots	26	108	193	China, Hong Kong
Green peas	302	236	250	Taiwan, China
Snow peas	2,513	1,696	4,855	Taiwan
Green soybeans	2,846	3,029	1,226	Taiwan
Okra	529	803	1,421	Thailand, Philippines
Celery[a]	n.a.	589	410	United States
Water chestnuts	106	172	237	China
Baby corn	67	177	134	Thailand, Philippines
Sweet corn[a]	n.a.	429	345	New Zealand, Taiwan

Source: Japan Vegetable and Fruit Import Safety Promotion Association, *Statistical Data of Imported Vegetables and Fruits* (Tokyo: JVFISPA, 1990).

Notes: These import quantities were recorded at seven major ports. n.a. is not available.

[a] These vegetables have been classified in trade statistics since 1988.

are not classified in the government trade statistics in addition to 37 fruits and 28 vegetables that are available in trade statistics.[4]

Commodities Selected for Research

Japan's dynamic import behavior provides a good indication of many aspects of the new trends in the world horticultural market. But detailed data on horticultural commodities are still limited to a small number of commodities. With these limitations and the focus of this study on developing countries, 10 commodities from Table 7 have been selected for detailed analysis. These are cut flowers, onions, green beans, bamboo shoots, ginger, bananas, pineapple, mangoes, avocados, and kiwifruit.[5] Bamboo shoots are further classified into two types, dried and canned, because they are different varieties and different in use. Differentiation is also made between ginger that is preserved (hereafter called "pickled ginger") and that which is not preserved (called "nonpickled ginger") because of their different uses. Frozen and canned pineapple, as well as fresh pineapple, play important roles in Japan's imports and in some developing country's exports; therefore all three types of pineapple are included. In total, 14 commodities are analyzed. Imports of these 14 commodities accounted for about 30 percent of the value of total horticultural imports in Japan during 1987-89. The major suppliers of these commodities are Taiwan, Thailand, the Philippines, Mexico, New Zealand, the Netherlands, the United States, and mainland China (Peoples Republic of China, hereafter called China). Each exports at least one of the 14 commodities to Japan.

Table 9 indicates the trade flows for the selected 14 commodities during the period 1979-81 to 1987-89. The growth of the value of imports varies greatly not only by commodity but also by source of imports. There is no commodity that has an even growth rate among its suppliers. Differences among suppliers are particularly large in cut flowers, prepared bamboo shoots, and pickled ginger; for the latter two commodities even the direction of growth is different between Taiwan and other suppliers. Foreign suppliers may be more interested in the value growth rates in U.S. dollars. During the period 1979-81 to 1987-89, the Japanese yen appreciated 62 percent so that the growth rates of import value in U.S. dollars were further increased by 5.9 percent annually above the rates expressed in yen. Therefore, all the foreign suppliers enjoyed higher earnings in U.S. dollars on horticultural exports to Japan than is shown in Table 9.

The import growth rates in value are subject to changes in both import quantity and import price. Table 9 presents movements in both quantity and price by trade flow. It is important to note that not only import quantities but also prices show different movements by source of supply for the same vegetable. Again, for some

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[4] Only import quantity data recorded at seven major ports are available for those fresh fruits and vegetables that are not classified in the trade statistics.

[5] Although asparagus and pumpkins are important imported vegetables in Japan and should be included in the analysis, trade data have been recorded only since 1988, and there are no price data available before that. Although kiwifruit are supplied by developed countries, they are included because their rapid growth may have implications for developing countries.

Table 9—Growth and price changes for Japan's imports of selected horticultural products, by country of origin, 1979-81 to 1987-89

Commodity/ Country of Origin	Import Value, 1987-89 Average	Growth Rate of Import Value	Growth Rate of Import Quantity	Change in Import Price/Year
	(Y million)		(percent)	
Cut flowers				
Taiwan	1,369	5.8	12.8	-5.8
Thailand	3,802	14.8	21.6	-5.2
Netherlands	3,738	84.2	93.0	-8.1
Total	12,225	16.7	18.6	-1.4
Onions				
Taiwan	538	-7.2	-3.4	-3.7
United States	1,580	-13.2	-4.9	-7.7
New Zealand	790	-12.9	-6.3	-6.3
Total	3,839	-11.8	-5.3	-5.9
Green beans				
Thailand	2,002	-8.2	-2.1	-6.3
Total	3,677	-4.8	1.1	-5.8
Bamboo shoots, dried				
Taiwan	5,370	4.7	-1.4	6.0
China	319	29.9	21.6	6.0
Total	5,701	5.2	-0.4	5.5
Bamboo shoots, canned				
Taiwan	2,628	-6.3	-8.1	0.9
Thailand	1,556	46.4	41.1	2.7
China	7,633	46.3	54.9	-5.9
Total	11,898	11.7	11.1	-0.3
Ginger, nonpickled				
Taiwan	412	11.3	10.6	0.7
Thailand	13	33.7	44.5	-6.4
China	275	3.3	12.0	-8.7
Total	783	6.6	10.9	-3.4
Ginger, pickled				
Taiwan	989	-11.9	-13.8	2.3
Thailand	3,113	36.2	36.9	-0.4
Total	4,564	5.1	5.1	-0.2
Bananas				
Taiwan	7,571	1.5	0.7	-1.6
Philippines	42,902	1.5	-1.2	0.4
Total	56,557	2.9	0.5	0.1
Mangoes				
Philippines	1,516	22.1	27.6	-4.3
Mexico	522	4.0	7.6	-3.2
Total	2,087	14.5	20.2	-4.7
Avocados				
Mexico	220	13.2	26.4	-10.6
United States	789	14.1	22.2	-6.7
Total	1,013	13.9	22.9	-7.5
Kiwifruit				
New Zealand	14,675	21.3	40.6	-14.8
Total	15,366	17.4	37.1	-15.3
Pineapple, fresh				
Taiwan	872	14.7	7.4	6.3
Philippines	8,829	-0.2	2.5	-2.6
Total	9,732	0.6	2.7	-2.1
Pineapple, frozen				
Taiwan	3	-47.4	-50.7	8.8
Thailand	1,034	-1.6	5.0	-7.1
Total	1,188	-4.9	0.7	-6.3

(continued)

Table 9—Continued

Commodity/ Country of Origin	Import Value, 1987-89 Average	Growth Rate of Import Value	Growth Rate of Import Quantity	Change in Import Price/Year
	(Y million)		(percent)	
Pineapple, canned				
Taiwan	284	-14.9	-12.3	-3.9
Philippines	1,046	-3.4	1.5	-5.8
Thailand	983	3.9	9.6	-6.1
Total	2,958	-3.0	1.9	-5.8

Source: Japan Tariff Association, *Japan Exports and Imports (Commodity by Country)* (Tokyo: JTA, various years).

Notes: Rates are compounded annually for the changes from 1979-81 average to 1987-89 average. Import values are evaluated at c.i.f. prices. Import prices are c.i.f. prices in Japanese yen adjusted by import tariff rates. China is mainland China.

commodities such as prepared bamboo shoots and both types of ginger, even the direction of price changes by supplier. This may occur because horticultural products are not homogeneous: varieties and production seasons vary from country to country. Therefore, it is important to distinguish horticultural imports not only by commodity but also by source of supply of each commodity.

For fruit imports the differences in growth rates among suppliers are also recognizable. For bananas and avocados, growth rates in value are similar among suppliers. However, the growth rate in quantity and changes in price differ for both commodities. Therefore, the similarity in growth of value among suppliers of bananas and avocados is not the result of similarity in Japan's import behavior.

The price of each trade flow may be determined independently of other trade flows and has to be examined individually, as Table 9 shows. Also the degree of differentiation and substitutability among trade flows varies by commodity and needs to be examined empirically. In the next chapter, a model that deals with trade flows differentiated by source of supply is presented, which is the basis of the following empirical analysis.

3

A MODEL OF IMPORT DEMAND FOR TRADE FLOWS

A Two-Stage Budgeting Theory

In the previous chapter it was observed that there are differences in Japan's import behavior not only among commodities but also among sources of supply of each commodity. This leads to a presumption that consumers differentiate between horticultural commodities by place of production. In dealing with Japan's import demand for horticultural products, therefore, it seems appropriate to adopt as a theoretical framework a two-stage budgeting procedure in which products are distinguished by their place of production and are not considered perfect substitutes for each other.

In general, for this procedure, it is assumed that consumers allocate their total expenditure in two stages. In the first stage, consumers allocate expenditure over broad groups of goods; in the second stage, the expenditure of each group is allocated to individual goods. The necessary and sufficient condition for the second-stage budget allocation is that the goods in a group are weakly separable from goods in any other group in consumer's utility function (see, for example, Strotz 1957; Pearce 1961; and Barten 1977).[6]

A consumer determines in the first stage the amount he or she wishes to spend on each group among m groups of goods so as to maximize utility,

$$U = U(Q_1, \ldots, Q_m), \tag{1}$$

subject to

$$Y = \sum_{i=1}^{m} Q_i P_i, \tag{2}$$

where U is the total utility of the consumer, Y is total expenditure, Q_i is the quantity index, and P_i the price index of group i, expressed as a function of quantities or prices of individual goods in group i:

$$Q_i = Q_i(q_{i1}, \ldots, q_{in}) \text{ and} \tag{3}$$

$$P_i = P_i(p_{i1}, \ldots, p_{in}), \tag{4}$$

where *in* is the number of goods in group i.

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[6] Weak separability in utility function means that the marginal rate of substitution between two goods from the same group is independent of the consumption of goods in other groups.

The first-stage demand for group i, Q_i^*, resulting from the first-stage expenditure allocation, is expressed as a function of the group price indices and total expenditure,

$$Q_i^* = Q_i^* (P_1, \ldots, P_m, Y) \tag{5}$$

The second-stage demands for individual goods in each group are determined, minimizing the cost to realize the first-stage demand level, Q_i^*, and expressed as a function of individual prices in the group and Q_i^*.

$$q_{ij}^* = q_{ij}^* (p_{i1}, \ldots, p_{in}, Q_i^*), \tag{6}$$

where Q_{ij}^* is the demand for good j in group i.

In the context of a trade allocation model, imports of a particular commodity are assumed to be weakly separable from any other good, including domestic products of the same commodity. In the first stage, the expenditure on imports of a commodity—mango, for example—is determined. Then the expenditure is allocated over individual import products from different countries, say mangoes from the Philippines, mangoes from Mexico, and so on, in the second stage. Therefore, the demand for each trade flow of a commodity can be expressed as a function of the individual import price by supplier of the commodity and the quantity index, which is determined in the first-stage budget allocation.

Import Demand Specification

To empirically analyze the horticultural imports of Japan, the import demand for each trade flow of a commodity in the second-stage is specified in a double-logarithmic form:

$$\ln M_i = \alpha_i + \sum_{j=1}^{n} \beta_{ij} \ln(PM_j/PM) + \gamma_i \ln(E/PM), \tag{7}$$

where M_i is the quantity imported from country i, PM_j is the price of imports from country j, E is the total expenditure on all imports of this commodity, and PM is Stone's geometric price index for imports of this commodity.

$$\ln PM = \sum_{j=1}^{n} w_k \ln PM_k \tag{8}$$

where w_k is the value share of country k in total imports.[7]

This model is homogeneous to degree zero in all the import prices and the total import expenditure. However, it is known that the theoretical restrictions of symmetry and adding-up in consumer behavior cannot generally be imposed on the double-log specification of the demand system (Deaton and Muellbauer 1980). It is desirable that the second-stage import demand equations are specified in a complete demand system such as the Almost Ideal Demand System, the Translog, or the

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[7] Note that in the specification of equations (7) and (8), a subscript representing a commodity is omitted and that the subscript i here refers to a source of imports.

Rotterdam models. However, when these models were applied to the trade flows of horticultural imports in Japan, preliminary examinations indicated that they did not result in statistically significant estimates of parameters. The double-log specification is a compromise with the reality that Japan's horticultural import performance not only reflects consumers' behavior, but also results from business activities of traders, who may not directly reflect consumers' preferences in their import businesses.[8] Moreover, the double-log specification makes it easier to manipulate the estimated coefficients in the growth-accounting analysis later in this report.

In the family of two-stage budgeting procedures, the most popular specification of the second-stage import demand is the Armington model (Armington 1969), which is often found in the agricultural trade literature (see, for example, Babula 1987; Grennes, Johnson, and Thursby 1977; Haniotis 1990; Ito, Peterson, and Chen 1988; Penson and Babula 1988; and Sarris 1983). The Armington model simplifies the second-stage import demand and summarizes it in a single parameter to be estimated, the elasticity of substitution among trade flows. Armington (1969) specifies the quantity index in equation (3) in the consumer's utility function as a constant elasticity of substitution (CES) form.[9]

$$Q = \left(\sum_{j=1}^{n} b_i q_i^{-\rho} \right)^{-1/\rho} \tag{9}$$

where Q is the quantity index of imports of a commodity, q_i is the import quantity from country i, and ρ is the parameter for the elasticity of substitution among the trade flows. Then the second-stage demands for individual trade flows are derived as follows:

$$q_i^* = b_i^\sigma Q (p_j/P)^{-\sigma} \tag{10}$$

where q_i^* is the demand for imports from country i, p_i is the price of imports from country i, P is the price index of import prices from all countries, and σ is the elasticity of substitution $[1/(1 + \rho)]$.

When equation (10) is expressed in logarithms and compared with equation (7), it appears that Armington's model, equation (10), is nested within the double-log model equation (7) for further restrictions on the parameters in the second-stage specification.[10] The restrictions are

- separability of each trade flow from other trade flows, even for imports of the same commodity, implying that only the own-price and group price indices are included as prices ($\beta_{ij} = 0$ for all $j \neq i$),
- homotheticity of trade flows on total expenditure on imports, implying that the import expenditure elasticity of any trade flow is unity ($\gamma_i = 1$ for all i), and

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[8] Therefore, the coefficients to be estimated are considered composite characteristics of Japan's import performance rather than characteristics of pure consumer demand.

[9] In the following expressions, the subscript representing a commodity is omitted.

[10] Although Armington used a CES price index for P in equation (10), his model expressed in percent changes uses an alternative form to first differentiate the logarithmic price index in equation (8).

- equality of the own-price coefficient for all the trade flows in the same commodity ($\beta_{ii} = \beta_{jj}$ for all i and j countries).

These restrictions make the model simple and tractable.[11] For example, all the cross-price elasticities between trade flows are calculated from the single elasticity of substitution and trade shares. Ease of use and flexibility are the reasons for the popularity of Armington's model in international agricultural trade research. However, such assumptions for simplification must be tested for validity before being applied.[12] Testing Armington's assumptions is particularly important for international trade modeling and computable general equilibrium (CGE) modeling (Alston et al. 1990). The double-log specification of equation (7) can be used to test easily and directly the Armington assumptions.

In connection with the trade-flow equations in the second stage, the first-stage demand equation for total imports of a commodity is specified in the following manner:

$$\ln M = \delta_0 + \delta_1 \ln (PM/PI) + \delta_2 \ln (PA/PI) + \delta_3 \ln (Y/PI) \qquad (11)$$

where M is the total import quantity index for a commodity appearing in the trade-flow equation (7), expressed as the expenditure on the total imports (E), divided by the price index of the imports (PM); PA is the price of substitutes for the imports; PI is the consumer price index of the importing country; and Y is the income of the importing country.[13]

Statistical Estimation and Data

To estimate statistically trade-flow equations and first-stage demand equations, an error term is added to equations (7) and (11). For trade-flow equations, the error term is assumed to have expectation zero and to be correlated with errors of other trade-flow equations in imports of the same commodity. For the latter, it is assumed that contemporaneous correlations among errors of the same commodity trade flows are reasonable because some disturbances, which are not captured by variables in the model, take place with regard to a specific commodity and their effects are considered common to all the trade flows of that commodity. Therefore, it is appropriate that trade-flow equations are estimated as a set by commodity. For this purpose, iterative techniques for seemingly unrelated regressions (SUR) devised by Zellner (1962) are used.

In SUR procedure, first, the covariance matrix of errors in the system is estimated, applying the ordinary least square (OLS) method to each equation in the system; then the covariance matrix is used to estimate the system's parameters, applying the generalized least-square method. The procedure is iterated, recomputing the covariance matrix with each new set of estimates until a convergence criterion is met.

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[11] Under these restrictions, the system of import demand satisfies the symmetry and adding-up conditions.

[12] Armington's assumptions were also examined theoretically by Winters (1984).

[13] Equation (11) is equivalent to the expenditure equation on total imports of the commodity if lnPM is added on both sides of the equation.

In cases where the first-order autocorrelation in errors is found in the early stage regressions in SUR procedure, the variables in the system are replaced by their first-order transforms in SUR estimation, using the method developed by Berndt and Savin (1975). Namely, if X_t is the original variable, it is replaced by $X_t - \rho X_{t-1}$ in SUR procedure, where ρ is the autocorrelation parameter.

For the first-stage import demand equations, the error term is assumed to have expectation zero and to be neither temporally nor contemporaneously correlated. Therefore, the first-stage import demand equations are estimated separately, using the OLS method, but corrected for first-order serially correlated errors if necessary.

In case there are structural changes in the first-stage import demand equations for a part of the estimation period, dummy variables are introduced that correspond to each explanatory variable in equation (11) for the period in which the demand structure is supposed to be changed; and these are tested for joint significance using Chow's test.[14] The dummies are constructed to take the values of each explanatory variable, including the constant term for the period of structural changes, and to take zero value otherwise. Thus, the parameter for the period of structural changes is obtained for each explanatory variable by adding the coefficient of the dummy to the coefficient of the corresponding original variable. To find the period of structural changes, Chow's test for joint significance of dummies is iterated, changing the period for dummies by annual increments; the period that shows the largest F-value is chosen as the period of structural changes, provided it is statistically significant. This procedure is necessary in an econometric analysis that uses time-series data of a country such as Japan, which has experienced rapid socioeconomic changes in a short period of time.

The data necessary for trade-flow equations are import quantity and price data by trade flow. Trade data for import quantity and value by commodity and country of origin are available from the Japan Tariff Association, *Nihon Boeki Geppyo* (Japan Exports and Imports: Commodity by Country). Import prices are calculated by dividing import value by import quantity and adjusting by tariff rates that are obtained from the Japan Tariff Association, *Jikko Kanzeivitsu Hyo* (Customs Tariff Schedules of Japan).

In addition to trade data, the first-stage import demand equations require data on prices of import substitutes and income and consumer price indices of the importing country (Japan). To determine the prices of substitutes, the consumer cut-flower price index, the consumer vegetable price index, and the consumer fruit price index are used. In addition, domestic market prices of onions and kiwifruit are introduced in the equations for those commodities, to take into account competition with domestic products of the same commodity; domestic production of onions and kiwifruit is substantial. Pickled and nonpickled ginger are close though not perfect substitutes, so the import price of pickled ginger is added to the equation for nonpickled ginger and vice versa.

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[14] Trade-flow equations are also subject to the test for structural changes. In the preliminary analysis, however, there were no significant structural changes discovered in any set of trade-flow equations.

All the domestic prices and price indices for Japan are obtained from the *Shohisha Bukka Shisu Nenpo* (Annual Report on the Consumer Price Index)(Japan Management and Coordination Agency, various issues). National income and population data are taken from *International Financial Statistics* (International Monetary Fund, various issues), and population data are used to define all the equations on a per capita basis to eliminate the effect of population growth. The estimation period differs by commodity depending on data availability.

4

EMPIRICAL RESULTS

Based on the model developed in the previous chapter, statistical estimations are conducted and reported in this chapter. The detailed results are presented in the Appendix, Tables 29-31 for the first-stage import demand equations and in Tables 32-39 for the trade-flow equations.[15]

In the estimation of first-stage import demand equations, Chow's test rejects structural stability for six commodities that show significant differences for a part of the estimation period. Therefore, dummy variables are introduced for those commodities, but only dummies that are statistically significant are included in the final estimation. Elimination of irrelevant variables increases the statistical efficiency of the coefficients of other variables (Pindyck and Rubinfeld 1981). For the same reason, those cross-price coefficients in trade-flow equations that are not statistically different from zero are eliminated in the final estimation.[16] This means that among the Armington assumptions, the separability of each trade flow from other trade flows in the same commodity is examined a priori. In this chapter, main results of estimations are used to characterize Japan's import demand for horticultural products.

First-Stage Import Demand

First, characteristics of Japan's horticultural import demand on a commodity basis are examined using the results of first-stage import demand equations. Table 10 summarizes import price and income elasticities of the first-stage import demand, which are interpreted in the same manner as conventional price and income elasticities by commodity. It may be convenient to discuss the characteristics of demand by cut flowers, vegetables, and fruits separately.

Cut-flower Imports

Among horticultural commodities, cut flowers are a major commodity, having grown rapidly in Japan's market. The import price and income elasticities of cut flowers in Table 10 are very large and statistically highly significant. This means

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[15] In the preliminary regressions, a lagged independent variable, a time trend variable, and a slope dummy for the trade flow equations for cut flowers and bananas were examined. Some were not statistically significant and others were not even consistent with the demand theory. The specifications adopted in the regressions, reported in the Appendix Tables 29-39, are based on those preliminary regression results.

[16] The critical value of t-distribution used for eliminating variables is 1.00. That is, those dummy and cross-price coefficients whose t-values are less than 1.00 are excluded.

Table 10—Estimated import price and income elasticities of first-stage demand for Japan's imports of selected horticultural commodities

Commodity	Import Price Elasticity (δ_1)	Income Elasticity (δ_3)
Cut flowers	-2.134**	2.303**
Vegetables		
Onions	0.313	-0.441[a]
Green beans	0.022	0.368*
Bamboo shoots, dried	-0.070	-0.211[a]
Bamboo shoots, canned	-0.752*	2.523**
Ginger, nonpickled	-1.720**	2.659
Ginger, pickled	-0.020	2.116**
Fruits		
Bananas	-0.557**[a]	-0.389[a]
Mangoes	-1.038**	3.546**
Avocados	-1.648**	0.994
Kiwifruit	-2.746**	1.765
Pineapple, fresh	-0.669*[a]	-0.129
Pineapple, frozen	-0.479[a]	-1.019[a]
Pineapple, canned	-0.007[a]	1.219*

Source: Results of regressions in the Appendix, Tables 29-31.

[a] These numbers are estimates for the period after structural changes.

*Significant at the .05 level.

**Significant at the .01 level.

that cut-flower imports are extremely sensitive to price and income changes and considered a luxury good in the sense that the demand increases faster than per capita income goes up.

In describing the Japanese demand for cut flowers, it is useful to consider consumption of cut flowers in three ways: flowers for commercial use, flowers for use in floral arrangements *(ikebana)*, and flowers for retail sales to individuals. Traditionally, imported flowers have mainly served commercial uses, such as banquets, weddings, funerals, and other ceremonies, because their prices are low and there is no need for the flowers to last a long time. In recent years, however, the demand for flowers as personal gifts has grown rapidly, and imported flowers have become common in flower shops. This corresponds to the fact that annual household expenditure on cut flowers increased 1.5 times from Y6,289 in 1980 to Y9,765 in 1989.

There are a number of reasons why individual Japanese are opting to give flowers as gifts. First, as the Japanese become more affluent, the desire to enjoy that affluence becomes more tangible. Second, amidst a profusion of material goods, sending flowers as a gift seems to express one's feelings more effectively. Third, the physical distribution system has become well established, with home-delivery service widely available, making it possible for people to order flowers with confidence (JETRO 1990, p.16). Imported flowers, which offer a wide range of choices, are benefiting from this expanding market.

Vegetable Imports

Vegetables selected in this report are limited to relatively traditional ones due to lack of data. As seen in Table 10, onions and green beans did not show the expected sign of import price elasticity, though neither is statistically significant.[17] For onions, this insensitivity to import price results from the role of imports in the domestic market. Onions are imported when domestic onions are in short supply and the domestic price soars because the commercial demand for onions for restaurants and for processed food industry uses is fixed. Then onion imports are increased by traders who speculate in onions even when prices abroad are the same or higher than normal years. Examples are sudden increases in onion imports from 77,000 tons in 1980 to 205,000 tons in 1981 and from 67,000 tons in 1983 to 158,000 tons in 1984. In the Appendix, Table 29, the detailed estimation results of onion imports indicate a large and highly significant coefficient of the domestic onion price variable. Therefore, the domestic market price is the dominant factor in the determination of onion imports.

The figures for bamboo shoots in Table 10 show quite different demand characteristics for dried and canned bamboo shoots. Whereas dried bamboo shoots have little sensitivity to either price or income changes, canned bamboo shoots are sensitive to both, especially to income changes. Dried bamboo shoots are called *menma* and are mostly used in soups, typically in noodle soups, whereas canned bamboo shoots are widely used in Japanese and Chinese cooking. Recent increases in demand for canned bamboo shoots are attributed partly to the increases in use by take-out lunch shops whose businesses have been rapidly growing.

Pickled and nonpickled ginger also have different characteristics and uses. Ginger is classified as a spice in trade statistics, rather than a vegetable, because it is commonly used for eliminating strong odors from meat or fish and also for flavoring soups and other dishes. Nonpickled ginger is used for this purpose, and import demand for this type of ginger is very price sensitive, having an import price elasticity of 1.72 (Table 10). In Japan, however, ginger is considered a vegetable because it is usually consumed as thinly sliced pickled ginger, which is served with *sushi*. The income elasticity for pickled ginger is large and stable because the demand for *sushi* increases as per capita income goes up; *sushi* is still a luxury good in Japan. Pickled ginger is also commonly used in Japanese take-out lunches called *bento*. The supplementary character of pickled ginger explains why it is sensitive to import price changes.

Fruit Imports

Imported fruits can be classified into two groups according to their demand characteristics. One group—bananas and the three types of pineapple—are traditional tropical fruits, demand for which is not very sensitive to either price or income changes. The other group consists of mangoes, avocados, and kiwifruit, which are relatively new fruits for Japanese consumers and characterized by large price and income elasticities.

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[17] Imported green beans are mostly black *matpes* and consumed in the form of bean sprouts.

Bananas are the most important imported fruit in volume. Bananas used to be a luxury for most Japanese, but since importation of bananas was liberalized in 1963, large supplies have become available at cheaper prices. In the late 1960s, multinational fruit corporations invested in banana plantations in the Philippines, targeting the Japanese market. Now, consumption of bananas seems to have reached the satiation point, as evidenced by a nonsignificant income elasticity in Table 10, although the demand is fairly price sensitive and highly significant.

Pineapple is similar to bananas, but canned pineapple are somewhat different from other types of pineapple. Canned pineapple is less sensitive to price but more sensitive to income changes than fresh and frozen pineapple. The price elasticity of canned pineapple is not significant mostly because imports of canned pineapple were restricted by import quotas until April 1990 when the import quota system for canned pineapple was abolished. Therefore, the quantity imported was bound by the quota and did not reveal the true demand, which resulted in an insensitivity of imports to price changes. The high income elasticity of canned pineapple is supported by a strong demand for use in cooking in family restaurants and take-out lunch shops.

In response to the removal of import quotas on canned pineapple, the demand for frozen pineapple is likely to shrink, because in the past frozen pineapple was imported and repacked in cans domestically, in order to meet the demand for canned pineapple over and above the quota. Such an incentive no longer exists.

Among the new fruits—mangoes, avocados, and kiwifruit—Japan's imports of all three are growing rapidly; the price elasticity of kiwifruit and the income elasticity of mangoes are remarkably large with high statistical significance. Although kiwifruit are not produced in developing countries at this time, the growth of kiwifruit consumption in Japan's market has many lessons for them. As shown in Table 7, imports of kiwifruit have increased by 37 percent per year for the last decade, a higher growth rate than any other fruit covered by trade statistics. The success has been based on a remarkable price decline of 15 percent annually for a decade. This high rate of price decline is not directly linked to recent appreciations of the Japanese yen, because New Zealand, the almost exclusive supplier of kiwifruit to Japan, offers prices in Japanese yen on kiwifruit trade contracts rather than in U.S. dollars. In point, New Zealand has reduced the price of kiwifruit and assumed the risk of exchange rate changes, thus making it easy for Japanese importers to expand imports steadily.[18]

The import demand for avocados also has been supported by price declines. Import prices of avocados from Mexico and the United States declined annually by 11 and 7 percent, respectively, during the last decade.

Mangoes, another major new commodity in horticultural imports in Japan, have the largest income elasticity among the commodities listed in Table 10. Mangoes are considered an exotic and luxurious commodity, as bananas used to be in Japan. Bananas are no longer used in fruit baskets for personal gifts, but mangoes are popular. The potential demand for mangoes is expected to be very large.

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[18] As the Japanese yen appreciates, New Zealand benefits from contracts based on the yen. But even when the yen depreciated in the early 1980s, the import price of kiwifruit in yen declined.

Trade-Flow Equations

The characteristics of Japan's import demand described for each commodity are not shared equally by all of the trade flows of that commodity. Estimated own-price coefficients and estimated import expenditure coefficients are summarized in Table 11, based on the detailed results of estimated trade-flow equations in the Appendix, Tables 32-39. Results are again discussed by commodity groups.

Cut-flower Trade Flows

Major suppliers of cut flowers to Japan are Taiwan, Thailand, and the Netherlands. The estimated coefficients of the three trade-flow equations for these suppliers of cut flowers are all highly significant, but the magnitudes of both their own-price and import expenditure coefficients differ by trade flow (Table 11). The demand for cut flowers from the Netherlands is the most sensitive to price change, followed by Thailand and then Taiwan; imports from the Netherlands are also most sensitive to income changes, followed by Taiwan and Thailand in that order. The product differentiation model by country of origin adopted in this study seems very suitable for analyzing cut-flower imports to Japan, because each exporting country provides different kinds of cut flowers. Taiwan exports mainly chrysanthemums; Thailand concentrates its exports on orchids; and the Netherlands supplies various kinds of cut flowers, such as freesias, tulips, lilies, roses, and carnations. The differences in magnitude of estimated coefficients by trade flow reflect differences in consumers' preferences for the various kinds of cut flowers. The statistical results indicate that cut-flower imports are "well-behaved" in the theoretical framework of product differentiation, with reasonable and stable estimates.

The trade-flow equations for cut flowers in Appendix Table 32 include a dummy variable. This was done to capture the effect of sales promotions by the Netherlands, which opened a Tokyo office in 1985. Their activities include advice to florists on new varieties, demonstrations of different ways of arranging them, and other services, which have stimulated the demand for Dutch flowers. Another factor favoring Dutch flowers is preshipment inspection of cut flowers so that they meet Japan's plant regulations, which the Netherlands started in late 1985, with Japanese quarantine officers dispatched to Amsterdam at the Netherlands' cost. Preshipment inspection simplifies quarantine procedures and reduces the risk of exports being rejected on arrival at Japan's airports. The effects of such promotional activities are captured by the introduction of a dummy variable set at a value of one for 1986-89 and zero otherwise in each trade-flow equation for cut flowers. The results indicate that the Netherlands gained significantly from such sales promotions by shifting Japan's import demand toward Dutch flowers and away from Taiwan, the major loser.

Vegetable Trade Flows

Although on a commodity basis import price elasticities were small, except for pickled ginger, many estimated own-price coefficients of vegetable trade flows show great sensitivity to relative price changes. Of 14 trade flows in vegetables, 9 have highly significant own-price coefficients at a 1 percent level. However, onions from Taiwan do not satisfy the sign conditions of the own-price coefficient.

Table 11—Estimated own-price and income expenditure coefficients of trade-flow equations for Japan's imports of cut flowers, selected vegetables, and fruits

Commodity/ Country of Origin	Own Price Coefficient (β_{ii})	Import Expenditure Coefficient (γ_i)
Cut flowers		
Taiwan	-1.337**	1.322**
Thailand	-1.650**	1.032**
Netherlands	-2.743**	1.624**
Vegetables		
Onions		
Taiwan	0.679	0.259*
United States	-2.191**	1.165**
New Zealand	-1.292	1.781**
Green beans		
Thailand	-2.053**	1.070**
Bamboo shoots, dried		
Taiwan	-2.755**	1.027**
China	-0.705	0.603
Bamboo shoots, canned		
Taiwan	-2.673**	-0.036
Thailand	-8.546**	3.071*
China	-2.090**	2.449**
Ginger, nonpickled		
Taiwan	-1.558**	1.753**
Thailand	-1.648	0.874*
China	-1.160**	0.054
Ginger, pickled		
Taiwan	-7.897**	0.731*
Thailand	-1.022	3.141**
Fruits		
Bananas		
Taiwan	-2.029**	1.603**
Philippines	-4.448	-0.765
Mangoes		
Philippines	-1.931**	0.588**
Mexico	-2.434**	1.924**
Avocados		
Mexico	-2.014**	0.662**
United States	-0.354	1.077**
Kiwifruit		
New Zealand	0.052	1.086**
Pineapple, fresh		
Taiwan	-0.365	2.115**
Philippines	-5.332**	1.777**
Pineapple, frozen		
Taiwan	-0.842	0.227
Thailand	-4.096**	2.908**
Pineapple, canned		
Taiwan	-4.317**	1.349**
Thailand	-0.700	1.013**
Philippines	-0.902	0.918**

Source: Results of regressions in the Appendix, Tables 32-39.
*Significant at the .05 level.
**Significant at the .01 level.

This irrational import behavior of onions from Taiwan may be partly attributed to the import cartel permitted in 1966 under the Export and Import Transaction Laws of the Japan Vegetable Importers Union to combat the monopolized exporting system in Taiwan. Under the cartel, quotas on onion imports from Taiwan were assigned. The import cartel, however, was abolished in 1987.

The sizes of own-price coefficients differ by source of supply in each set of trade flows. The own-price coefficients of Thailand in canned bamboo shoots and Taiwan in pickled ginger are exceptionally large, but other own-price coefficients are in a range between −0.7 and −2.8, excluding onions from Taiwan, as mentioned before. Thailand increased its exports of canned bamboo shoots through relative price declines that took advantage of this large own-price coefficient of import demand, while Taiwan, which used to be the dominant supplier of canned bamboo shoots, lost its market share quickly due to relative price increases in the late 1980s. The observed differences in own-price coefficients by trade flow justify the assumption that consumers distinguish vegetable products by place of production, even though the products are called by a common commodity name.

These findings, combined with the result of import price elasticities in Table 10, indicate that, although vegetable imports are relatively insensitive to price changes on a commodity basis, once the total amount to be spent for imports of a vegetable is determined, then the Japanese seek cheaper products so that price competition among suppliers is inevitable.

The differences by country of origin are also observed in the coefficients of the import expenditure variable. If the import expenditure coefficient is unity (one), demand for that trade flow is homothetic, and it expands at the same rate as total imports of the commodity. In other words, the market share of the trade flow does not change unless relative prices change in homothetic demand. If the estimated coefficient of the import expenditure variable is significantly greater than unity, it is a good indication for an exporting country that its exports can expand more than others and its share increase as Japan's market grows. But if the coefficient is significantly less than unity, the exporter cannot enjoy expansion of exports for that trade flow commensurate with the growth of Japan's market.

Among the vegetable trade flows, canned bamboo shoots from Thailand and China and pickled ginger from Thailand have relatively large estimates of the import expenditure coefficient, while the estimates for canned bamboo shoots from Taiwan and for nonpickled ginger from China are very small. However, it must be statistically tested to judge if the coefficient is significantly greater or smaller than unity. This can be done with a chi-square test and will be examined later, together with Armington's assumptions.

Fruit Trade Flows

Table 11 also summarizes the estimated own-price and import expenditure coefficients of fruit trade flows. On the own-price coefficients, each commodity has at least one trade flow that shows a significantly larger coefficient than others. Exceptions are mangoes, whose trade flows have similar own-price coefficients, and kiwifruit, for which New Zealand dominates the trade flows, so that the own-price of New Zealand kiwifruit relative to the total import price does not fluctuate enough, resulting in an insignificant own-price coefficient.

The sharp contrast of own-price coefficients in the same commodity reflects the dynamic aspect of Japan's fruit trade, in which particular trade flows rise and fall in price competition. One example is the rapid expansion in the mid-1970s of exports of bananas and fresh pineapple from the Philippines to Japan, after investments in Philippine plantations by multinational corporations enabled the Philippines to offer cheaper prices than other suppliers. In frozen pineapple, the sharp increase in share that Thailand experienced in the 1970s also resulted from price competition among suppliers.

In contrast to these success stories, canned pineapple from Taiwan has experienced a decline. Taiwan used to be a major supplier of canned pineapple to Japan, enjoying a large market share until the early 1970s. But in the course of its rapid economic growth as one of the Newly Industrializing Economies, Taiwan lost its comparative advantage in labor-intensive industries such as the canning industry due to increasing labor costs.[19] Appreciation of the new Taiwan dollar against the U.S. dollar of more than 40 percent between 1986 and 1989 also hurt exporting industries in Taiwan and priced products out of many foreign markets.

Estimated coefficients of import expenditure variables in fruit trade flows also show wide variations. Among the large coefficients, those of bananas and fresh pineapple from Taiwan deserve attention. Japanese consumers consider Taiwan bananas to be of higher quality because the shorter transporting distance means less spoilage and because the variety grown in Taiwan is sweeter than that grown in the Philippines. As a result, Taiwan bananas are priced higher than Philippine bananas in the market. This may partly explain the differences in their coefficients. The large import expenditure coefficient of fresh pineapple from Taiwan is partly attributed to recent increases in imports of a new variety, Tainung No. 4, which has gained popularity because of its high sugar content and because its skin is easily peeled so that it can be picked apart with fingers and eaten without cutting.

The import expenditure coefficient of frozen pineapple from Thailand shows the largest value among the fruit trade flows in the study, reflecting a quick shift of Japan's source of imports from Taiwan to Thailand in the early 1980s, which cannot be explained by price competition. This happened partly because importers expected Taiwan to lose competitiveness with rapid increases in its wage rate. Mangoes also indicate a substantial difference in the import expenditure coefficient between the Philippines and Mexico. One reason for this is a difference in the variety of mangoes grown in the two countries: mangoes from the Philippines are mostly pelican mangoes, which are not as sweet as the apple mangoes grown in Mexico. All the estimated coefficients of the import expenditure variable are subject to the statistical test for homotheticity, which will be conducted in the next section.

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[19] Taiwan was also driven out of the market by relative price increases in canned bamboo shoots for the same reason. Production of fresh vegetables and fruits is also labor-intensive, but response may lag behind wage increases because farmers may not explicitly take into account their own-labor cost in production costs, and farm labor may not be easily relocated to nonfarm uses. This partly explains why some of the estimated price elasticities for fresh vegetables and fruits are less than those of canned bamboo shoots from Taiwan.

Meanwhile, trade-flow equations for banana imports in the Appendix Table 37 include a dummy variable to represent the effects of sales promotions by the multinational fruit corporations, such as Polly Peck International, Castle and Cook, and United Brands, which have developed massive sales promotions for their respective brand names, Del Monte, Dole, and Chiquita, to penetrate the Japanese market. In this attempt to capture the effects on trade flows of the promotion activities, the dummy variable takes a value of one for 1969-89 and zero otherwise. The statistical results imply that the sales promotions allowed the Philippines to export more bananas to Japan than they would have without the promotions. Taiwan suffered a loss of market share in Japan.

Statistical Tests

The estimated coefficients for trade flows are subjected to statistical tests that serve several purposes. First, the coefficients of the import expenditure variable are tested against the homotheticity hypothesis for individual trade flows. If the import expenditure coefficient of a trade flow is greater than unity, the exporter of the trade flow gains by growth in Japan's market for imports of that commodity. On the other hand, those exporters who have import expenditure coefficients less than unity cannot take advantage of Japan's market growth.

To determine if a coefficient is significantly different from unity, chi-square tests are used against the hypothesis $H_0 : \gamma \leq 1$ for those with estimated coefficients greater than one, or against the hypothesis, $H_0 : \gamma \geq 1$ for those with estimated coefficients less than one. The results are summarized in Table 12. Of the 31 trade flows under study, 13 show import expenditure coefficients significantly greater than unity; these are called "market-favored" trade flows. Six trade flows appear to have coefficients significantly less than unity, and these are called "market-disfavored." The coefficients of the 12 remaining trade flows are not significantly different from unity, and thus are called "market-neutral."

It is worth noting that all the trade flows from Thailand and developed countries are classified as market-favored or market-neutral, meaning that all trade flows from those countries benefit from Japan's market growth. Trade flows from Taiwan, the Philippines, Mexico, and China are split into three groups, depending on commodity. The differences in the magnitudes of the import expenditure coefficients are compounded results from differences in product quality, consumers' preferences, business partnerships, political alliances, and other factors. To identify the real reasons behind these differences, a more detailed study by trade flow is required.

In the following statistical tests, Armington assumptions are examined. As discussed in Chapter 3, the Armington model is a nested model within the double-log specification imposing restrictions of separability (β_{ij} = for all $j \neq i$), homotheticity ($\gamma_i = 1$ for all i), and equality of own-price coefficients ($\beta_{ii} = \beta_{jj}$ for all i and j) on the system jointly. Among the assumptions, separability is examined a priori in the process of trade-flow equation estimations. It is not rejected for green beans, pickled ginger, bananas, mangoes, kiwifruit, and fresh pineapple. Therefore, the cross-price coefficients in trade flows of those commodities are set at zero in the final estimation.

Table 12—Results of the chi-square test for homotheticity of individual trade flows with the estimates of the import expenditure coefficient (γ_i)

Commodity	$\gamma_i > 1$[a]	$\gamma_i = 1$[b]	$\gamma_i < 1$[c]
Cut flowers	Taiwan Netherlands	Thailand	. . .
Vegetables			
Onions	New Zealand	United States	Taiwan
Green beans	. . .	Thailand	. . .
Bamboo shoots, dried	. . .	Taiwan China	. . .
Bamboo shoots, canned	China	Thailand	Taiwan
Ginger, nonpickled	Taiwan	Thailand	China
Ginger, pickled	Thailand	Taiwan	. . .
Fruits			
Bananas	Taiwan	. . .	Philippines
Mangoes	Mexico	. . .	Philippines
Avocados	United States	. . .	Mexico
Kiwifruit	New Zealand	. . .	. . .
Pineapple, fresh	Taiwan Philippines	. . .	. . .
Pineapple, frozen	Thailand	Taiwan	. . .
Pineapple, canned	. . .	Taiwan Thailand Philippines	. . .

Note: H_o is the null hypothesis and γ_i is the import expenditure coefficient.

[a] Trade flows that rejected the null hypothesis H_o: $\gamma_i \leq 1$ at the 10 percent level.

[b] Trade flows that did *not* reject H_o: $\gamma_i = 1$ at the 10 percent level.

[c] Trade flows that rejected H_o: $\gamma_i \geq 1$ at the 10 percent level.

The results of testing homotheticity, equality, and all Armington assumptions jointly on the final estimates (given in the Appendix, Tables 32-39) are summarized in Table 13. Chi-square test statistics show that individual assumptions are not rejected at the 10 percent level of significance in four cases (green beans, dried bamboo shoots, avocados, and canned pineapple) against homotheticity of all import expenditure coefficients, and they are not rejected against equality of all own-price coefficients in two cases (nonpickled ginger and bananas). However, full Armington restrictions are rejected in all 14 commodities in the study at the 10 percent significance level. The results imply that Armington's approach may not be appropriate for analysis of Japan's trade in the horticultural commodities selected, although the individual assumptions that were not rejected by the statistical tests can be used in modeling for those commodities.

Elasticities of Trade Flows

The coefficients estimated for first-stage import demand equations and for trade-flow equations can be combined to derive the elasticities of trade flows, which represent total effects of changes in explanatory variables on trade flows. By substituting the related first-stage import demand equations of a commodity into a trade-flow equation, followed by total differentiation, the own-price elasticity and income elasticity of the trade flow can be expressed as follows:

Table 13—Chi-square statistics for testing Armington assumptions in trade-flow equations

Commodity	Homotheticity $\gamma_i = 1$	Equality $\beta_{ii} = \beta_{jj}$	Armington $\beta_{ij} = 0, \beta_{ii} = \beta_{jj}, \gamma_i = 1$
Cut flowers	87.6	12.6	463.6
Vegetables			
Onions	44.3	10.0	78.7
Green beans	0.1*	. . .	. . .
Bamboo shoots, dried	0.6*	23.4	42.5
Bamboo shoots, canned	57.9	12.1	240.2
Ginger, nonpickled	105.2	1.3*	146.2
Ginger, pickled	38.7	20.2	45.1
Fruits			
Bananas	6.2	0.6*	6.3
Mangoes	12.3	6.2	20.9
Avocados	4.1*	6.2	8.4
Kiwifruit	22.9	. . .	. . .
Pineapple, fresh	22.8	18.3	47.1
Pineapple, frozen	24.5	5.4	50.1
Pineapple, canned	3.0*	7.3	38.1

Note: γ_i is the import expenditure coefficient and β_{ij} is the price coefficient.
*Chi-square statistics not significant at the 10 percent level.

$$\varepsilon_i = \beta_{ii} - w_i \left(\sum \beta_{ij} - \gamma_i \delta_1 \right), \text{ and} \tag{12}$$

$$\eta_i = \gamma_i \delta_3 , \tag{13}$$

where ε_i is the own-price elasticity and η_i is the income elasticity of demand for a trade flow from country i; w_i is the value share of country i in total imports; β, γ, and δ are the coefficients that appear in the trade-flow equations and the first-stage import demand equations.

The calculated own-price and income elasticities of trade flows based on equations (12) and (13), using the estimated coefficients and 1987-89 average value shares, are presented in Table 14. In the calculation, those coefficients that have wrong signs in the estimates are set at zero to avoid inconsistency. It is important for exporting countries to know the elasticities by trade flow in order to identify the characteristics that differentiate their products from others in the Japanese market.

The calculated own-price elasticities show impressively how price-sensitive Japan's demand is for individual trade flows. In Table 14, 20 trade flows out of a total of 31 have own-price elasticities valued greater than one in absolute value. Even among those elasticities that are less than one, six are greater than 0.5. These large own-price elasticities, particularly those greater than one, indicate that the exporting countries could not only increase the quantity of exports, but also their earnings from the exports by making an effort to lower prices by reducing the costs of production, marketing, and distribution. Large own-price elasticity is a general characteristic of horticultural commodities, but such a characteristic is not equally attached to all trade flows. Variations in the size of own-price elasticities by

Table 14—Calculated own-price and income elasticities of trade flows for selected horticultural products to Japan

Commodity/ Country of Origin	Own-Price Elasticity[a] (ε_i)	Income Elasticity (η_i)
Cut flowers		
Taiwan	-1.766	3.044
Thailand	-2.128	2.377
Netherlands	-2.952	3.741
Vegetables		
Onions		
Taiwan	-0.348	-0.114
United States	-1.373	-0.514
New Zealand	-1.339	-0.786
Green beans		
Thailand	-0.926	0.394
Bamboo shoots, dried		
Taiwan	-0.236	-0.217
China	-1.194	-0.127
Bamboo shoots, canned		
Taiwan	-2.181	-0.091
Thailand	-9.666	7.745
China	-1.930	6.178
Ginger, nonpickled		
Taiwan	-2.632	4.662
Thailand	-1.644	2.326
China	-0.691	0.143
Ginger, pickled		
Taiwan	-6.142	1.547
Thailand	-0.374	6.648
Fruits		
Bananas		
Taiwan	-1.876	-0.624
Philippines	-0.755	0.298
Mangoes		
Philippines	-0.974	2.085
Mexico	-2.324	6.822
Avocados		
Mexico	-1.809	0.659
United States	-1.804	1.070
Kiwifruit		
New Zealand	-2.850	1.918
Pineapple, fresh		
Taiwan	-0.459	-0.273
Philippines	-1.572	-0.229
Pineapple, frozen		
Taiwan	-0.840	-0.231
Thailand	-2.859	-2.966
Pineapple, canned		
Taiwan	-5.126	1.644
Thailand	-0.471	1.235
Philippines	-0.584	1.119

Note: Elasticities are calculated using estimated coefficients in the Appendix, Tables 29-39, and average value shares for 1987-89.

[a] For the import price and own price coefficients estimated with a positive sign, the value was set at zero.

commodity and also by trade flow are wide. That is, own-price elasticities are different for, say, canned bamboo shoots from Taiwan than they are for canned bamboo shoots from Thailand.

The calculated income elasticities are also widely scattered. Japan's economic growth, accompanied by higher per capita income, does not necessarily lead all trade flows to prosperity. The trade flows listed in Table 14 are classified into two groups according to the magnitude of their income elasticities. One group consists of 16 trade flows whose income elasticities are greater than one. This group can expand its exports as Japan's economy grows. In particular, the 10 trade flows of the 16 in this group that have income elasticities greater than two are very likely to continue to prosper. The most prosperous trade flows include those in cut flowers, canned bamboo shoots, ginger, and mangoes.

The income elasticities calculated by trade flow are naturally subject to the income elasticities for individual commodities as well. But some trade flows with relatively large income elasticities on a commodity basis do not enjoy the same demand growth as that commodity because the coefficient of import expenditure in trade-flow equations is small. Examples are canned bamboo shoots from Taiwan, nonpickled ginger from China, and avocados from Mexico.

The second group consists of 15 trade flows whose income elasticities are less than one, including the three trade flows mentioned. All the trade flows with low income elasticities are traditional horticultural commodities such as onions, green beans, dried bamboo shoots, bananas, and fresh and frozen pineapple. Reflecting some negative income elasticities on a commodity basis, 11 trade flows in this group have negative income elasticities. Although the negative values of trade-flow income elasticity are based on insignificant estimates of commodity income elasticities, trade flows in this group contrast with those in the first group. In other words, the spectrum of income elasticity indicates a kind of polarization of trade flows into those with very high income elasticities and others with very low or even negative income elasticities.

The differences in price and income elasticities by trade flow within the same commodity observed in some cases in Table 14 may include the effects of traders who developed new sources of imports and shifted their partners from one country to another, especially in the course of the recent appreciation of the yen. Most horticultural commodities are traded by relatively small traders, whose business is very volatile. Bananas and pineapple, which are produced and traded by multinational corporations, are the exception. As long as the small traders have freedom of exit and entry, they ensure the competitive nature of the market. The large price and income elasticities in Table 14 reflect such a market structure for horticultural imports into Japan.

5

ACCOUNTING FOR IMPORT GROWTH

The characteristics of Japan's import demand for horticultural products described in the previous chapter play important roles in the growth of imports. The factors that contributed the most to import growth are demand-side price and income changes. The coefficients estimated for first-stage import demand equations and for trade-flow equations can be used to evaluate the contributions of price and income factors to import growth; they can also indicate the size of the change in each price and income variable.

Accounting for Commodity Import Growth

First, the growth rates of commodity imports are examined. The import growth rate of a commodity, which is measured by the annual growth rate of the import quantity index defined for the first-stage import demand equations, is a result of changes in factors that appeared as explanatory variables in the equation. To identify the degree of change contributed by each factor, the growth rate of the import quantity index for a commodity is decomposed using the following growth-accounting equation derived from the first-stage import demand equation (11):

$$G(M) = \delta_1 G(PM/PI) + \delta_2 G(PA/PI) + \delta_3 G(Y/PI), \qquad (14)$$

where G denotes percent changes of the variable in parentheses [$G(x) = dx/x$]; M and PM are the commodity's import quantity and price indices; PA is the price of substitutes for the import; Y is income; PI is the consumer price index; and δ_1, δ_2, δ_3 are the parameters in the first-stage import demand equation. In other words, the contribution of each explanatory variable in the demand equation is the product of a percentage change of the variable by the coefficient in the demand equation.

The growth-accounting equation (14) is then applied to explain the growth of commodity imports between the 1979-81 average and that for 1987-89.[20] The results, summarized in Table 15, indicate that the model used in the analysis explains the import growth in the 1980s well; residuals are small compared with the realized growth rates for most commodities. Cut flowers, both types of ginger, and fresh pineapple, whose residuals are less than 10 percent of the realized growth rates, are explained especially well by the factors of import price, substitute price, and income changes. On the other hand, the residuals for green beans, bananas, and

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[20] In growth accounting, those coefficients that have wrong signs in the estimates are set at zero to avoid inconsistency.

Table 15—Factors accounting for Japan's import growth in selected horticultural products, 1979-81 to 1987-89

Commodity	Import Growth Rate[a]	Contribution of Changes in			Total Contribution	Residual
		Import Price	Substitute Price[b]	Income		
			(percent)			
Cut flowers	17.63	7.02	6.48	5.87	19.36	-1.74
Vegetables						
Onions	-5.88	0.00[c]	-3.14	-1.12	-4.26	-1.62
Green beans	0.44	0.00[c]	0.05	0.94	0.99	-0.55
Bamboo shoots, dried	-1.18	-0.25	0.00[c]	-0.54	-0.79	-0.39
Bamboo shoots, canned	10.48	1.73	0.00[c]	6.43	8.16	2.32
Ginger, nonpickled	11.28	11.17	-6.54	6.78	11.41	-0.13
Ginger, pickled	4.39	0.04	-1.34	5.39	4.10	0.29
Fruits						
Bananas	-0.08	1.14	-0.42	-0.99	-0.27	0.20
Mangoes	19.46	6.87	-0.18	9.04	15.72	3.73
Avocados	22.45	15.58	0.00[c]	2.53	18.12	4.34
Kiwifruit	36.34	45.45	-21.20	4.50	28.74	7.60
Pineapple, fresh	1.95	2.59	-0.26	-0.33	2.00	-0.05
Pineapple, frozen	-0.31	3.74	-0.62	-2.60	0.52	-0.82
Pineapple, canned	1.21	0.06	-0.55	3.11	2.62	-1.41

Note: Growth-accounting is conducted for the changes from 1979-81 to 1987-89, using compounded annual growth rates of the following variables: import price, the price of substitutes, and income, all divided by the consumer price index.

[a] Based on annual growth rate of the per capita import quantity index for each commodity.

[b] The contribution of changes in alternative prices is included.

[c] The coefficient of the variable is set at zero because the estimate had the wrong sign.

frozen and canned pineapple are relatively large compared with the realized growth rates, which nevertheless are the lowest in Table 15.

For individual commodities, import price, substitute price, and income changes contribute almost equally to import growth in cut flowers. For other commodities, however, a single dominant factor contributes more to import growth than other factors. Import growth in six commodities is supported mainly by import price changes. The import growth rates of avocados, kiwifruit, and fresh pineapple are explained exclusively by import price changes. In vegetables, the contribution of import price changes to nonpickled ginger is remarkably large.

For another six commodities, Japan's income growth is the major factor explaining the import growth: canned bamboo shoots, pickled ginger, and mangoes have particularly large contributions from income growth. The import growth of onions is explained mainly by substitute price changes, that is by changes in the domestic market price of onions. The declines in onion imports from 1979-81 to 1987-89 can be attributed mainly to price declines in the domestic market.

Accounting for Trade-Flow Growth

The growth-accounting method can also be applied to the growth of trade flows. Combining the trade-flow equation (7) with the first-stage equation (11) in the same manner as in elasticity derivation for trade flows, a growth rate of a trade flow is decomposed as follows:

$$G(M_i) = (\beta_{ii} - W_i B_i)G(PM_i) + \sum_{k \neq i}^{n}(\beta_{ik} - W_k B_i)G(PM_k)$$

$$+ \gamma_i \delta_2 G(PA) + \gamma_i \delta_3 G(Y) - \gamma_i(\delta_1 + \delta_2 + \delta_3)G(PI), \qquad (15)$$

where

$$B_i = \sum_{j=1}^{n}\beta_{ij} - \gamma_i \delta_1 ,$$

and G again denotes percent changes of the variable in parentheses following G. Thus, the import growth rate of a commodity from country i, $G(M_i)$, is the sum of contributions of own-price changes, $G(PM_i)$; competitor's price changes, $G(PM_k)$; substitute price changes, G(PA); Japan's income growth, G(Y); and Japan's inflation rate, G(PI), all multiplied by a related coefficient.[21]

The results of accounting for trade-flow growth between 1979-81 and 1987-89 are presented in Table 16 for cut flowers and vegetables and in Table 17 for fruits.[22] The contributions of price and income changes are compared with the realized growth rate of each trade flow that appeared in Table 9 in Chapter 2.[23]

Reflecting the large own-price elasticities that characterize most horticultural trade flows, many trade flows show substantial contributions of own-price changes to import growth; the contributions of own-price changes are shown in the diagonal elements in the price change blocks in Tables 16 and 17. Indeed, 19 trade flows out of 31 have own-price changes as the most important factor determining the import growth rate between 1979-81 and 1987-89. It is noteworthy that even trade flows of those commodities that showed small contributions of import price changes in Table 15 have large contributions from own-price changes. Examples are onions from the United States and New Zealand, bamboo shoots from China, and pickled ginger and canned pineapple from Taiwan.

The importance of price changes in trade-flow growth is extended to price changes in competitor's products. In some cases the contribution of competitor's price changes exceeds any contribution of other factors, whether of positive or negative value.[24] These cases include trade flows of onions, canned bamboo shoots, nonpickled ginger, bananas, and canned pineapple from Taiwan, as well as bamboo shoots from Thailand.

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[21] Coefficients of G are elasticities of the trade flow with respect to the variable in parentheses following G.

[22] Again, if the estimated coefficient has a wrong sign, the value is set at zero.

[23] The coefficients used in growth-accounting are based on the estimates of per capita trade-flow equations and per capita first-stage demand equations. Therefore, the total contribution is adjusted, including the population growth rate, to make it comparable to the realized trade-flow growth rate.

[24] The sign of contributions of competitor's price changes is not necessarily the same as the direction, because the effect of competitor's price changes on the import price index may exceed the substitution effect if the competitor's share is large, whereas the sign of contributions of own-price changes is always opposite to the direction of own-price changes.

Table 16—Factors accounting for Japan's import growth in cut flowers and selected vegetables, by country of origin, 1979-81 to 1987-89

Commodity/ Contry of Origin	Import Growth Rate[a]	Contribution of Price Changes					Contribution of Income Changes	Total Contribution[d]	Residual
		Country A[b]	Country B[b]	Country C[b]	ROW[b]	Substitutes[c]			
					(percent)				
Cut flowers									
Taiwan (A)	12.81	10.24	-0.09	8.95	-0.21	8.56	7.76	34.38	-21.57
Thailand (B)	21.59	-4.36	11.15	3.43	1.90	6.69	6.06	30.01	-8.42
Netherlands (C)	92.96	0.47	1.23	23.86	0.94	10.52	9.53	81.96	11.00
Onions									
Taiwan (A)	-3.43	1.28	-0.25	-5.30	1.30	-0.81	-0.29	-3.46	0.02
United States (B)	-4.94	-1.37	10.50	-2.80	-1.39	-3.65	-1.31	0.58	-5.52
New Zealand (C)	-6.32	-5.47	0.67	8.48	0.15	-5.58	-2.00	-3.14	-3.18
Green beans									
Thailand (A)	-2.06	5.84	. . .	. . .	-4.44	0.06	1.00	3.07	-5.14
Bamboo shoots, dried									
Taiwan (A)	-1.44	-1.43	0.95	. . .	0.03	. . .	-0.55	-0.24	-1.20
China (B)	21.62	5.56	-7.18	. . .	1.06	. . .	-0.32	-0.19	21.81
Bamboo shoots, canned									
Taiwan (A)	-8.06	-1.95	0.77	-10.22	-1.58	. . .	-0.23	-12.66	4.60
Thailand (B)	41.08	11.61	-25.87	32.87	0.48	. . .	19.74	44.18	-3.10
China (C)	54.93	0.05	0.09	11.43	-0.01	. . .	15.74	31.70	23.23
Ginger, nonpickled									
Taiwan (A)	10.59	-1.83	-2.87	9.47	-1.43	-11.46	11.88	10.57	0.02
Thailand (B)	44.50	0.04	10.49	-0.55	-0.09	-5.72	5.93	13.80	30.70
China (C)	11.99	0.32	-0.16	6.04	-0.67	-0.35	0.36	6.35	5.64
Ginger, pickled									
Taiwan (A)	-13.77	-13.95	-2.34	. . .	1.20	-0.98	3.94	-11.48	-2.30
Thailand (B)	36.93	0.48	0.16	. . .	0.15	-4.20	16.94	14.28	22.66

Note: Growth-accounting is conducted for the changes from 1979-81 to 1987-89 using compounded annual growth rates of variables: own price, competitors' prices, the price of substitutes, income, and the consumer price index.

[a] Based on annual growth rate of import quantity by country of origin.

[b] Country A, B, and C are the countries listed in the first column for each commodity, and ROW is the rest of the world.

[c] Includes the contribution of changes in alternative prices.

[d] Includes the population growth rate, the dummy variable effect for cut flowers, and the inflation effect on import expenditure.

Table 17—Factors accounting for Japan's import growth in selected fruits, by country of origin, 1979-81 to 1987-89

Commodity/ Contry of Origin	Import Growth Rate[a]	Conribution of Price Changes					Contribution of Income Changes	Total Contribution[d]	Residual
		Country A[b]	Country B[b]	Country C[b]	ROW[b]	Substitutes[c]			
					(percent)				
Bananas									
Taiwan (A)	0.68	3.07	0.34	...	-0.07	-0.68	-1.59	3.52	-2.84
Philippines (B)	-1.18	-1.08	-0.29	...	-0.29	0.32	0.76	-0.84	-0.33
Mangoes									
Philippines (A)	27.61	4.22	-1.06	...	-0.05	-0.11	5.31	10.18	17.43
Mexico (B)	7.58	-1.37	7.42	...	-0.02	-0.35	17.38	27.80	-20.22
Avocados									
Mexico (A)	26.42	19.19	-4.78	...	...	...	1.68	18.95	7.47
United States (B)	22.16	-0.41	12.07	...	...	...	2.73	18.66	3.50
Kiwifruit									
New Zealand (A)	40.64	42.16	...	...	2.06	-23.04	4.89	32.82	7.82
Pineapple, fresh									
Taiwan (A)	7.35	-2.90	2.49	...	0.04	-0.56	-0.70	1.90	5.45
Philippines (B)	2.51	2.34	4.11	...	-0.15	-0.47	-0.58	8.31	-5.80
Pineapple, frozen									
Taiwan (A)	-50.73	-7.39	-4.49	...	-0.18	-0.14	0.59	-11.95	-38.78
Thailand (B)	4.95	0.03	20.16	...	-2.84	-1.81	-7.56	11.47	-6.52
Pineapple, canned									
Taiwan (A)	-12.30	20.00	16.98	-33.34	-14.55	-0.74	4.19	-6.82	-5.48
Philippines (B)	1.54	-0.34	3.38	-1.80	-1.11	-0.50	2.85	3.10	-1.56
Thailand (C)	9.57	-0.26	-1.42	2.86	-0.86	-0.55	3.15	3.54	6.03

Note: Growth-accounting is conducted for the changes from 1979-81 to 1987-89 using compounded annual growth rates of variables: own price, competitors' prices, the price of substitutes, income, and the consumer price index.

[a] Based on annual growth rate of import quantity by country of origin.

[b] Country A, B, and C are the countries listed in the first column for each commodity, and ROW is the rest of the world.

[c] Includes the contribution of changes in alternative prices.

[d] Includes the population growth rate, the dummy variable effect for cut flowers, and the inflation effect on import expenditure.

The trade flows of canned bamboo shoots present an interesting example of price competition. As seen previously in Table 9, China alone decreased its price by 5.9 percent annually, whereas Taiwan and Thailand increased their prices by 0.9 and 2.7 percent, respectively. Therefore, the sign of the own-price change contribution is positive for China and negative for the other two, and the size of the contribution is a product of the price change rate by the own-price elasticity. The effects of China's price decline on imports from Taiwan and Thailand are interesting: the two competitors are led in different directions—Taiwan to negative growth and Thailand to positive growth.

China is the major supplier of canned bamboo shoots, accounting for 64 percent of Japan's imports in 1987-89. Therefore, the price decline in China causes a significant decline in the import price index of canned bamboo shoots, which in turn results in an increase in expenditure on total imports of canned bamboo shoots through the first-stage import demand equation. Such an increase in import expenditure benefits Thailand multiplicatively because Thailand has a large coefficient for the import expenditure variable in the trade-flow equation for canned bamboo shoots, as seen in the Appendix, Table 34. If the effect of the increase in import expenditure exceeds the substitution effect brought about by China's price decline in the trade-flow equation, China's price changes will contribute to positive growth in the competitor's exports, as happened in Thailand. On the other hand, the increase in import expenditure does not bring any change in Taiwan's exports because its coefficient of the import expenditure variable is negligible. Therefore, the substitution effect of the decline in the import price index through both own-price and cross-price variables in the trade-flow equation is dominant, and the contribution of China's price decline to growth of Taiwan's exports is negative.

Income changes are a product of Japan's income growth rate by the income elasticity of the trade flow.[25] Income growth is the most important single factor contributing to the growth of eight trade flows. Income growth contributed remarkably to the import growth of canned bamboo shoots from Thailand and China, nonpickled ginger from Taiwan, pickled ginger from Thailand, and mangoes from Mexico. Income contributions are purely proportional to the income elasticities of trade flows in Table 14 because Japan's income growth rate is the common factor by which all income elasticities are multiplied.

Contributions of individual factors sum to the total contribution.[26] The calculated total contribution may be interpreted as a potential import growth rate for each trade flow in the sense that it depends on the purified characteristics of Japan's import demand and on the trends of changes in independent variables. The differences between the realized import growth rates and the total contributions, which appear as residuals in the last columns in Tables 16 and 17, are unexplained. Sixteen of the 31 trade flows recorded positive residuals, which means that the realized import growth rate was higher than the potential growth rate, indicating better performances of imports than expected. Positive residuals are particularly large for both types of bamboo shoots from China, both types of ginger from Thailand, and mangoes from the Philippines.

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[25] The income growth rate and the price change rate of substitutes are defined in real terms so that the effect of inflation is taken into account for these variables.

[26] The total contribution includes the inflation effect on import expenditure, the dummy variable effect for cut flowers, and the population growth rate, which is necessary because the estimated equations are for per capita imports.

On the other hand, there are 15 trade flows for which negative residuals are recorded. The realized growth rates of these trade flows fell short of the total contributions and did not reach the potential growth rates for the 1979-81 to 1987-89 period. Particularly large negative residuals are recorded for the trade flows of cut flowers and frozen pineapple from Taiwan and mangoes from Mexico.

It is difficult to identify the factors that prevented these trade flows from realizing their potential growth rates. Differences between realized growth rates and total contributions are certainly subject to statistical errors in the estimated coefficients and random errors in 1979-81 or 1987-89. Residuals that are small relative to the realized import growth rates may be the result of such errors. However, the large residuals should be examined individually to look for other causes. Further investigation of residuals requires more detailed information on the market structure and related data for individual trade flows, but at this stage of research, three factors may be worth mentioning.

The first deals with quarantine regulations. Although phytosanitary regulations, which will be discussed in the next chapter, are faced by all horticultural imports, the ratio of rejected imports to planned imports as a result of imposed regulations may differ by source of imports. For example, in cut-flower trade, as mentioned in the previous chapter, the Netherlands have reduced the risk of rejection by introducing preshipment inspections. A part of the effects of this special treatment was captured by the dummy variable introduced in trade-flow equations for cut flowers, but the effects may go beyond that, resulting in significant differences in residuals between the Netherlands and the other two exporters.

The second factor is the market structure for imports. If the market tends to be less competitive, leaning toward monopsony, the price may divert demand, resulting in negative residuals. The coefficients applied for growth-accounting were mostly estimated using data for a longer period than 1979-81 to 1987-89. If the market structure has changed in recent years, the estimated coefficients tend to represent the previous structure more than the changed one, and the residual becomes larger than can be explained by statistical error. Imports of bananas and pineapple, which recorded negative residuals, used to be very competitive, with many small importers, but the number of importers was reduced dramatically in the course of market integration. Bananas and pineapple are now imported by a handful of large importers. This change may partly explain the negative residuals of banana and pineapple imports. To test this hypothesis, a formal empirical model of imperfect competition would be needed.

Finally, the importance of sales promotions by exporters should be emphasized. (These were already discussed for cut flowers and bananas in Chapter 4.) The success in mango exports from the Philippines to Japan is also the result of aggressive sales promotion by several Philippine exporters. Their activities included approaching the Japanese government to obtain official approval of their method of fumigation, which caused the ban on imports of mangoes from the Philippines to be lifted. Such efforts have probably resulted in a much higher import growth rate for Philippine mangoes than expected.

6

JAPAN'S POLICY AND DOMESTIC DISTRIBUTION

Policies on Horticulture

Imported horticultural products enter the market and are sold in competition with the domestic produce of Japan. Most imports of horticultural products, however, do not directly conflict with domestic products because of differences in kind and variety. For example, the most important domestic products in Japan are daikon radishes, cabbages, and Chinese cabbages in vegetables, and *mikans* (mandarin oranges), apples, and Japanese pears in fruits. Nevertheless, imported horticultural products do substitute to some extent for domestic products, as shown by the estimated positive coefficients of the substitute price variables in some regressions for import demand in the previous chapters. Therefore, in considering import growth, it is also important to examine Japan's domestic policies on horticulture.

In Japan, about 80 percent of farm households produce some vegetables, but most of these are for home consumption. The number of farms that marketed horticultural products were 606,000 for vegetables and 527,000 for fruits in 1990 (JMAFF 1990). They supply about 90 percent of the vegetables and 65 percent of the fruits consumed in Japan. Although Japanese agriculture is characterized by part-time farmers who typically produce rice, the staple crop, horticultural commodities are supplied mostly by full-time or nearly full-time farmers. More than 60 percent of horticultural output is produced on core farms, which are defined as farms with at least one economically active male (16-55 years old) engaged in farming for more than 150 days per year. In contrast the share of rice output produced by core farms is less than 30 percent (JMAFF 1989a). This means that the structure of horticultural production in Japan is sound, with professional farms that are land-saving and capital-intensive enterprises, especially in greenhouse vegetable production. Indeed, horticulture is one of the few agricultural industries that attracts young people to engage in agricultural careers in Japan.

Horticultural producers are more market-oriented and more responsive to market signals than other agricultural producers, partly as a result of less government intervention in this sector than in other agricultural sectors. Horticultural growers receive little direct support from the government despite the fact that cut flowers, vegetables, and fruits now account for about one-third of total agricultural production in gross output value. In other words, the horticultural industry has grown mainly through private efforts and without government intervention.

Nevertheless, horticultural growers are not perfectly independent of protection policies. For some producers of vegetables and fruits, a price support system is operated by the Vegetable Supply Stabilization Fund and the Fruit Supply Stabilization Fund, respectively. In Japan the market prices of horticultural products are determined by auction in wholesale markets. As discussed later in this chapter, the prices determined by auction tend to fluctuate broadly and the shippers or producers cannot reject the sales of their products in auction even at a price lower than the cost. When market prices fall steeply, subsidies are paid to farmers to avoid severe income losses, making up the difference between the market price and a guaranteed level for the farmers' shipments. For example, the Vegetable Supply Stabilization Fund subsidizes the producers through registered shipping organizations for designated vegetables shipped on behalf of producers from 1,187 designated production areas to 34 designated consumption areas. The guaranteed price level is determined by taking into consideration past trends in market prices, production costs, and other economic factors; it is not directly or systematically related to border prices. The central government, prefectural governments, and shipping organizations all contribute to the funds required. Fourteen vegetables, including onions, are under this system.[27] In addition, nonprofit organizations set up in prefectures under the Civil Code carry out purchase, sale, and storage of vegetables as required, and grant subsidies to some vegetables other than the 14 designated ones (Masuda 1990). A similar system is operated by the Fruit Supply Stabilization Fund, which covers mandarin oranges, apples, pears, and peaches (for processing only).

From the exporter's point of view, border measures such as import tariffs, import quotas, and other nontariff barriers are a concern. The import quota on oranges has been publicized as a symbol of the closed nature of Japan's agricultural markets. But most import quotas have been removed. Among the commodities in this study, imports of canned pineapple were restricted by an import quota, but it was abolished in 1990.

Import tariff rates have also been reduced through bilateral or multilateral trade negotiations. The current tariff rates are summarized in Table 18.[28] In assessing duty for imports from developing countries, a preferential rate is applied before a GATT rate, a GATT rate before a temporary rate, and a temporary rate before a general rate. Therefore, most import tariff rates for developing countries are already low, except those on bananas and pineapple. Import tariff rates on bananas have been reduced gradually, but they are still as high as 20 percent on bananas imported during the period from October 1 to March 31, although rates are reduced to 10 percent for the rest of the year.[29] This seasonal differential tariff was introduced because domestic fruits, particularly apples, were thought to suffer from competition with bananas in the seasons when domestic products are in the market.

Unlike bananas, the import tariff rate on fresh pineapple has not changed at all, staying at 20 percent for more than 20 years. Because of the trend toward a general reduction in tariff rates over time, however, this fixed tariff rate on fresh pineapple gives the impression of a high barrier. The barrier against imports of pineapple,

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[27] They are cabbages, cucumbers, taros, Japanese radishes, onions, tomatoes, eggplants, carrots, Welsh onions, Chinese cabbages, potatoes, sweet peppers, spinach, and lettuce.

[28] Basic data on horticultural imports to Japan, including tariff rates since 1965 and quantities, values, prices, and exchange rates, are available as a supplement to this report from the International Food Policy Research Institute.

[29] In the import demand analysis in Chapter 5, the import price of bananas is adjusted by the average of the two seasonal tariff rates weighted by the import quantity for each season.

Table 18—Japanese import tariff rates on selected horticultural products, 1989

Commodity	General	GATT	Preferential	Temporary
			(percent)	
Cut flowers	10	Free	Free	. . .
Vegetables				
Onions (1)[a]	10	. . .	. . .	10
Onions (2)[b]	10	. . .	. . .	Formula[c]
Onions (3)[d]	10	. . .	. . .	Free
Green beans	Free	Free	. . .	. . .
Bamboo shoots, dried	15	. . .	7.5	. . .
Bamboo shoots, canned	25	. . .	. . .	16
Ginger, nonpickled	10	5	Free	5
Ginger, pickled	15	. . .	. . .	. . .
Fruits				
Bananas (1)[e]	30	. . .	10	40
Bananas (2)[f]	30	. . .	20	50
Mangoes	20	. . .	4	. . .
Avocados	20	. . .	4	. . .
Kiwifruit	20	8	8	. . .
Pineapple, fresh	20	. . .	. . .	. . .
Pineapple, frozen	20	. . .	. . .	28
Pineapple, canned	45	30	. . .	55

Source: Japan Tariff Association, *Customs Tariff Schedules of Japan* (Tokyo: JTA, 1989).

[a] Not more than Y 67 per kilogram in value for customs duty.

[b] More than Y 67 per kilogram but not more than Y 73.70 per kilogram in value for customs duty.

[c] (Y 73.70 − the value for customs duty)/kilogram.

[d] More than Y 73.70 per kilogram in value for customs duty.

[e] If imported during the period from April 1 to September 30.

[f] If imported during the period from October 1 to March 31.

especially canned pineapple, protects pineapple growers in Okinawa, where the domestic pineapple industry is concentrated. They ship their products to the major islands in Japan mostly in canned form. After the abolition of the import quota on canned pineapple in 1990, a tariff quota system was introduced on canned pineapple imports. Under this system, in exchange for purchasing one unit of canned pineapple from Okinawa, a trader is given a tariff quota by which 4.8 units of canned pineapple can be imported from abroad duty free. Otherwise, a 30 percent tariff is imposed on canned pineapple imports.

Japan's policies on horticulture seem less restrictive against imports than those of the EC countries, which form the largest horticultural market in the world. In addition to the Common Agricultural Policy (CAP) provisions, which support prices of fresh vegetables and fruits by compensating producers for withdrawing selected commodities from the market during the period of surplus, EC producers are protected from low-price imports from third countries by a reference price system. The system is operated so that when the import price for a particular commodity in a representative EC market fails below the reference price for a qualifying period, the importer is assessed an additional levy, or countervailing duty, equal to the difference between the reference and the import price. Nineteen types of vegetables and fruits are covered by this reference price system in the European Community. Thus, the reference prices act as minimum import prices, sometimes having prohibitive effects on imports, especially on tomato imports

(Alvensleben 1982 and Buckley 1990). The European Community also applies relatively higher tariffs on some commodities to keep imports from benefiting from the internal price support system (Buckley 1990). Meanwhile, several major countries and regions that produce horticultural products have established accords in order to receive preferential duty rates—the Lomé countries, for example. Furthermore, in the case of bananas, free circulation within the European Community is largely restricted by the national legislation of each member country. For example, the United Kingdom protects imports of bananas from the Caribbean against imports from other countries, France protects imports from Côte d'Ivoire and Cameroon, Italy protects imports from Somalia, and Spain protects imports from the Canary Islands. All member states of the European Community, except Germany, apply custom duties on imports of bananas from the dollar area; Germany imposes a duty-free quota covering its total consumption (Fairclough 1989).

Quarantine Regulations

Of the barriers against horticultural exports to Japan, the major concern for most developing countries is Japan's phytosanitary regulations. Japan's quarantine regulations are often criticized by exporters who consider them too restrictive and even irrational. It is difficult to distinguish unnecessary restrictions from necessary ones because standards and safety concerns about food sanitation, disease, and infestation differ widely by country. Following is a general description of Japan's quarantine regulations for plant imports, which are applied not only to vegetables and fruits, but to all other kinds of plants as well.

Because Japan is totally surrounded by seas and followed a policy of seclusionism for many years (1639-1854), invasions of pests and diseases from overseas were largely precluded. Once a pest or disease finds its way into Japan, however, there is great danger of its staying in the country, because the Japanese territory is oriented north to south, its climate varies widely from subarctic to subtropic, and cultivated land or farms are continuous. For these reasons, particular importance is attached to quarantine of plants in Japan. Although Japan failed to stop entry of fall webworm, potato tubeworm, and rice-water weevil, the entry of more harmful pests and diseases, such as fruit flies, codling moths, and potato wart diseases, have so far been prevented (JETRO 1986). Table 19 lists the countries from which plant imports are prohibited because of pests.

Japan requires that plants be brought into the country through a designated seaport or airport, with a plant inspection application form and a phytosanitary certificate issued by the plant quarantine authority of the exporting country attached. These must be submitted to the plant quarantine station, and the plants inspected by a plant quarantine officer. If the plant is found free from harmful pests or diseases the certificate of inspection is issued: if any pest or disease is detected, the certificate of inspection will be issued after disinfection has been completed.

After the regular quarantine inspection conducted at the time of import is over, fruit tree seedlings, flower bulbs, tuberous roots of sweet potatoes, tubers of potatoes, and live stems and leaves of sugarcane are required to undergo postentry cultivation for a preset period in order to detect possible viruses and other diseases that may not be found by the regular quarantine inspection.

Table 19—Major prohibited fruits, vegetables, and other plants

Regions and Countries from which Importation is Prohibited	Main Prohibited Items	Pests and Diseases
Europe, Middle and Near East, Africa, Australia, Brazil.	All fresh fruits (excluding fresh pineapple and coconut and fresh unripe banana), walnut in husks	Mediterrannean fruit fly, codling moth.
United States (excluding Hawaii), Canada, New Zealand	Fresh fruits such as apple, pear, plum, cherry, and walnut, wheat straw	Codling moth, Hessian fly
Hawaii	All fresh fruits (excluding fresh pineapple and coconut, and fresh unripe banana)	Mediterranean fruit fly, mango fly, melon fly
China	Fresh apple, pear, cherry, and walnut	Codling moth
China, Taiwan, Hong Kong, the Philippines, Indonesia, Thailand, Malaysia, Singapore, Burma, India, Pakistan, Guam, Saipan	Fresh citrus fruits such as ponkan, tankan, pompelmous, and lime, and fresh plum, papaya, longan, litchi, carambola, guava, avocado, rambutan, mango, star apple, sapodilla, eugenia, anona, mangosteen, eggplant, tomato, capsicum, watermelon, cucumber, momordica, pumpkin, and fresh ripe banana	Mango fly, melon fly
Tahiti, Easter Island, New Caledonia, Papua New Guinea	Fresh citrus fruits such as orange, fresh papaya, carambola, guava, avocado, passion fruit, mango, eugenia, anona, kiwifruit, date, and fresh ripe banana	Queensland fruit fly

Source: JETRO (Japan External Trade Organization), *Plant Quarantine in Japan* (Tokyo: JETRO, 1986).

Notes: Besides the list, the following are also prohibited entry: Some plants with roots or underground parts from the United States (including Hawaii) for possible presence of burrowing nematode (Radopholus citrophilus); rice plant, rice straw, rice husk, and unhulled rice from all regions and countries except the Korean Peninsula and Taiwan; and soil and plants with soil.

Plants that are prohibited may sometimes be imported if they are processed in the following manner: immersed in salt, sugar, sulfurous acid, or other approved substances; dried; heated; or frozen at a temperature of−17.8°C or lower.

Even the ban on plants prohibited under the Plant Quarantine Law may be lifted if predetermined conditions are met and public hearings are held. Technical reasons for the ban will no longer exist when the following conditions are satisfied:

- The pests in question have been exterminated in the country of origin and that fact is confirmed by Japanese experts.
- A technology for totally exterminating the pests in the country of origin has been established, and that technology is confirmed to be 100 percent effective by Japanese experts.

The countries and plants that have been authorized under this system are listed in Table 20.

The methods of disinfection in use have been established by each exporting country through repeated tests run over a number of years and include such

Table 20—Commodities and countries for which the ban has been lifted and treatments accepted

Country/Area	Commodity	Pest	Disinfection Method
Philippines	Mango	Mango fly, melon fly	Vapor heat treatment
Israel	Orange, lemon, grapefruit	Mediterranean fruit fly	Cold treatment
United States	Cherry	Codling moth	Methyl bromide fumigation
	Walnut, in shell	Codling moth	Methyl bromide fumigation
	Nectarine	Codling moth	Methyl bromide fumigation
Hawaii	Papaya	Mediterranean fruit fly, mango fly, melon fly	Vapor heat treatment
Canada	Cherry	Codling moth	Methyl bromide fumigation
Australia	Orange	Mediterranean fruit fly, Queensland fruit fly	Cold treatment
South Africa	Orange, lemon, grapefruit	Mediterranean fruit fly	Cold treatment
Swaziland	Orange, grapefruit	Mediterranean fruit fly	Cold treatment
New Zealand	Cherry, nectarine	Codling moth	Methyl bromide fumigation
Taiwan	Tancan orange, ponkan orange, Liutin variety of sweet orange	Mango fly	Vapor heat treatment or cold treatment
	Litchi	Mango fly	Vapor heat treatment
	Papaya	Mango fly, melon fly	Vapor heat treatment
	Mango	Mango fly, melon fly	Vapor heat treatment
Thailand	Mango	Mango fly, melon fly	Vapor heat treatment
Chile	Grape	Mediterranean fruit fly	Cold treatment
China	Hamigua	Melon fly	From domestically inspected areas
Spain	Lemon	Mediterranean fruit fly	Cold treatment

Source: Japan Vegetable and Fruit Import Safety Promotion Association, *Statistical Data of Imported Vegetables and Fruits* (Tokyo: JVFISPA, 1990).

methods as fumigation with methyl bromide, low temperature treatment, and heat treatment. Ethylene dibromide (EDB) used to be extensively used for fumigation and disinfection, but it has been banned in Japan since 1988 because of its suspected carcinogenicity. The United States has also banned the use of EDB and restrictions on EDB are a worldwide trend.

With this new development, exporters who relied on EDB fumigation had to change their method of disinfection. For example, when mango exporters in the Philippines switched to more costly vapor heat treatment, the export price of Philippine mangoes jumped from US$1.20 per kilogram in 1987 to US$1.85 per kilogram in 1988.[30] The increases in export costs have spurred a reorganization of the mango industry in the Philippines, in which mangoes are produced and exported by relatively large growers and exporters to take advantage of scale economies; small producers and exporters are no longer able to export mangoes at the same price as before.

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[30] In an interview with Philippine fruit exporters, it was reported that the cost of fumigation with EDB is about 10 cents per kilogram of mangoes in U.S. dollars, whereas the vapor heat treatment costs about 60 cents per kilogram.

Japan's phytosanitary regulations have brought a number of complaints from exporters, identifying many specific problems. For example, vegetables are fumigated if a single aphid is present despite the fact that aphids are "cosmopolitan pests" and commonly found in Japan. Japan is concerned about different "biotypes" and thus requires fumigation to avoid infestation with a mutant strain of aphid. The same applies to quarantine restrictions for Latania scale. Scale is commonly found in Japan, yet fumigation is required if the pest is found during port inspection (CSWTC 1986). Some complaints are also directed toward inspection operations. To cope with rapidly increasing imports of horticultural products, the number of air cargo inspectors and fumigation chambers were increased. However, the number of food sanitation inspectors has not increased enough for prompt inspection. The number of hours taken for inspection is crucial for exporters because most horticultural products are perishable and a delay in delivery may result in quality deterioration.

In the Uruguay Round negotiations of the General Agreement on Tariffs and Trade (GATT), the contracting countries have tried to establish a system of multilateral rules and descriptions to guide the application of sanitary and phytosanitary measures, and to develop standard guidelines and recommendations with respect to all aspects of sanitary and phytosanitary measures. Harmonizing sanitary and phytosanitary measures is now on the agenda for international trade talks. In the Uruguay Round, however, progress toward an agreement in this field has been blocked by the deadlock in agricultural negotiations to reduce protection policies in developed countries.

Any government may interfere with traded agricultural products on health and safety grounds, but they should do so only when the scientific evidence justifies it. In addition to scientific investigations, it is also important to identify the effects on trade of technical barriers. The technical barriers may be classified into groups according to their roles. Lynham (1987) suggests the following classification:

- Protective: restrictive trade practices that increase the price (cost of production and marketing) of imported goods.
- Trade-diverting: restrictive trade practices that divert trade across firms or countries because of the differential or prohibitive cost of compliance.
- Trade-neutral: restrictive trade practices that affect the cost of all producers and hence increase the consumer price of both domestic production and imports.

Since this framework identifies the increased cost of discriminatory quarantine regulations, a tariff equivalent or a nominal rate of protection could be calculated (Bredahl and Forsythe 1989). Such a task could be conducted through international collaboration, as producer and consumer subsidy equivalents are calculated by the Organization of Economic Cooperation and Development.

Domestic Distribution

Countries that export horticultural products are also concerned about Japan's distribution system, which their products must pass through. Domestic producers and import traders can sell their commodities through wholesale markets or directly to supermarkets and large processors, restaurants, school lunch centers, and others.

Wholesale markets account for nearly 100 percent of sales of cut flowers and 80-90 percent of vegetables and fruits in normal trading. Therefore, wholesale markets are the key to understanding the distribution system for horticultural products in Japan.

There were 91 central wholesale markets in 56 cities and 1,691 local wholesale markets spread across Japan in 1986. The purchasers of horticultural products in the wholesale market are intermediate wholesalers who sell the products to retailers or large users. Because today's wholesale markets are overly subdivided into regions, the possibility of integrating them is being examined, to rationalize distribution and allow a wider selection of products at each wholesale market. Indeed, in Tokyo metropolitan area, such integration has already started. A large central wholesale market was opened in 1989 with expected daily transactions of 125,000 cut flowers, 3,000 tons of fruits and vegetables, and 300 tons of fishery products.

The most important role of wholesale markets in Japan is price formation by auction. The prices of products in wholesale markets are determined by competition among purchasers, given a fixed amount of supply a day. The auction is conducted under the regulations of the Wholesale Market Laws. Only wholesalers who have a license can sell the products, but they are just consignees entrusted by shippers of produce or import traders and cannot receive more than the consignment fee. The wholesalers cannot reject any consignment by shippers without a justified reason and can sell only the products actually delivered to the market.

Therefore, in a sense, the auction is very competitive, and there is little possibility of price control, whereby price formation in wholesale markets is considered "fair." However, for those commodities with small price elasticities, the price determined in the auction tends to fluctuate widely as the daily supply changes. Once shippers consign their products to wholesalers, the shippers cannot reject the sales of their products, even if the auctioned price is lower than the cost. One method of avoiding this risk is to disperse shipments to wholesale markets throughout the country.

For import traders, it is risky to auction imported commodities that are contracted at a fixed price with exporters. Traders tend to sell the products directly to intermediate wholesalers, large users, and supermarkets, bypassing the wholesale markets. For buyers who demand a fixed amount of a product daily, such as processors, restaurants, and take-out lunch businesses, it is desirable to secure a stable supply with a contract. In addition, some large supermarket chains have networks and pipelines of imports and, therefore, purchase the imports through their own routes. As a result, the ratio of imported vegetables and fruits sold by auction is smaller than that of domestic products, although imported cut flowers are sold mostly through wholesale markets.

The final stage in the distribution of horticultural products is the retail market. Horticultural products, particularly fresh vegetables, are the commodities most frequently purchased daily by consumers because freshness is the most important factor, given their perishable nature. In Japan, 74 percent of consumers purchase vegetables every day or every other day and 78 percent purchase at retail shops within a 15-minute walking distance from home (Toda 1989). This explains why there are so many retail shops that sell horticultural products in Japan: about 130,000 retail shops sell vegetables and fruits and 25,000 sell flowers. Most of them are small in size, and their annual sales averaged less than 20 million yen in 1986.

Through the distribution system described above, horticultural products are delivered to consumers. The prices consumers pay for the products reflect both production and distribution costs. Table 21 shows the composition of retail prices for six vegetables and fruits. The composition differs by commodity but, roughly speaking, distribution costs account for 50-70 percent of the retail price, and the amount paid to producers is less than half of the retail price. The margin at retail levels is especially large, accounting for 30-50 percent of the retail price. The high ratio of distribution costs in marketing channels is observed not only in Japan but also in other countries. For example, in the United States, the margin accounts for 47 percent of the retail price for lettuce and 43 percent of the retail price for oranges (Takahashi 1991). The distribution costs for bananas are particularly large, though the figures for bananas cannot be directly compared with other commodities in the list because of different sources of data. The margin for bananas at the wholesale level includes tariffs and processing costs for ripening because the import price is c.i.f., and only green bananas are imported due to quarantine restrictions. Nonetheless, the margin for bananas at retail is much higher than at wholesale, accounting for about half of the retail price.

The composition of retail prices indicates how important the distribution costs are in the formation of prices for horticultural commodities. Improvements in efficiency of the distribution system have long been recommended as essential for

Table 21—Distribution costs of six vegetables and fruits, 1988

Commodity	Producer Price (1)	Wholesale Price (2)	Retail Price (3)	Margin at Wholesale (2-1)[a]	Margin at Retail (3-2)[b]	Distribution Costs (3-1)
			(Y/10 kilograms)			
Onions	638	1,050	1,700	412 (24.2)	650 (38.2)	1,060 (62.5)
Cabbages	1,001	1,378	2,067	377 (18.2)	689 (33.3)	1,066 (51.6)
Tomatoes	3,469	4,500	7,000	1,031 (14.7)	2,500 (35.7)	3,531 (50.4)
Mandarin oranges *(mikans)*	1,989	2,689	4,111	700 (17.0)	1,422 (34.6)	2,122 (51.6)
Apples	2,272	3,100	5,277	828 (15.7)	2,177 (41.3)	3,005 (56.9)
Bananas	730[c]	1,170	2,320	440 (19.0)	1,150 (49.6)	1,590 (68.5)

Source: JMAFF (Japan, Ministry of Agriculture, Forestry, and Fisheries), *Horticultural Statistics* (Tokyo: Norin Tokei Kyokai, 1989).

Note: Results are from a survey conducted in November 1988, except for bananas, for which the figures are the 1988 average at each stage of distribution. Figures in parentheses are the percentage of the retail price.

[a] Includes shipping cost from farmgate to wholesale market.

[b] Includes margin for intermediate wholesalers.

[c] This is the c.i.f. import price.

reducing consumer prices, which in general are higher in Japan than in other developed countries. One development that has contributed to a more efficient distribution system is the increase in supermarkets. Supermarkets take advantage of scale economies and provide cheaper commodities with wider selections. Consumers have been significantly influenced in their shopping patterns by the increase in supermarkets. In 1964 about three-quarters of fresh vegetables (in value) were purchased at ordinary retail shops, but by 1984, that figure dropped to less than 40 percent by 1984 (Toda 1989). Today, more than half of the fresh vegetables are distributed through supermarkets in Japan.

In the wake of rapid increases in supermarkets in the early 1970s, the Large Retail Store Law was enacted in 1974 to protect small retailers from competition with large retailers. The law regulates the opening of major retail operations and applies to outlets with a selling space of 500 square meters (5,382 square feet) or more. Large retailers who are interested in opening a new outlet are required to have the plan approved by the Chamber of Commerce and Industry and the retailers's group in the region. The details of the plan are also examined by a council of local retailers, consumers, and academics. In the process, changes to the plan may be recommended. The procedure is finalized by the Minister of International Trade and Industry. It takes years to complete this procedure. The Large Retail Store Law is also viewed as a barrier to the entrance of foreign-made goods into Japanese markets. Indeed, the law was a top item on the agenda of the talks on the Structural Impediments Initiative (SII) between Japan and the United States in 1990, and Japan promised to cut the time it takes to complete the approval process to less than 18 months.

The cost efficiency of distribution through large retailers is shown in Table 22, which indicates retail costs of vegetable and fruit sales by types of retail shops. There are significant differences in retail costs for both vegetable and fruit sales between supermarkets and ordinary small shops whose annual sales are less than 30 million yen. Sale of one ton of vegetables costs the small shops Y65,000 added to the cost of the commodities at retail, whereas it costs supermarkets just Y53,000 on the same sales—about 20 percent less than the cost of the small shops. The ratio is about the same for fruit sales, too. The differences result mainly from economies of scale that supermarkets can exploit with a larger volume of sales. The amount of sales determines the costs of retail business as seen in the differences between ordinary shops whose sales are more than Y30 million and those whose sales are less; the former are 15 percent more efficient than the latter. Table 22 also shows the cost factors of land and building rent and labor cost. Surprisingly, there is not much difference in the ratio of land and building rent to the total cost by type of shop, but the share of labor costs in supermarkets is clearly smaller than that of ordinary shops, even larger shops.

Wide selection and lower prices are the key factors explaining the rapid expansion of sales through supermarkets. Low price is still an important factor, but at present competition among retail shops centers more on quality and variety than on price. Consumers in Japan are willing to pay higher prices for higher quality, and they are also looking for something different in the products they purchase. This is particularly true for cut flowers and fruits, where many different varieties are available in the same shop to meet different demands. Retail shops that sell horticultural products tend to be separated into two different types; one concen-

Table 22—Retail costs of vegetable and fruit sales, 1987

	Ordinary Shop with Sales of		
Item	Less than Y 30 million	More than Y 30 million	Supermarket
	(Y/metric ton)		
Vegetable sales			
Land and building rent	6,579	5,478	4,808
	(10.1)	(9.9)	(9.9)
Labor cost	38,690	33,777	29,507
	(59.3)	(61.2)	(55.3)
Total cost	65,249	55,153	53,337
	(100.0)	(100.0)	(100.0)
Fruit sales			
Land and building rent	6,581	6,023	4,806
	(8.8)	(9.3)	(7.8)
Labor cost	44,741	39,048	33,293
	(60.1)	(60.4)	(54.1)
Total cost	74,458	64,648	61,495
	(100.0)	(100.0)	(100.0)

Source: JMAFF (Japan, Ministry of Agriculture, Forestry, and Fisheries), *Horticultural Statistics* (Tokyo: Norin Tokei Kyokai, 1989).

Notes: These figures are the results of a survey conducted for large cities. Figures in parentheses are the percent of the total cost.

trates on products of high quality and high prices, and the other deals in large volume and low prices. Therefore, production and imports on the supply side are also expected to reorganize in this direction.

Reduction in Distribution Costs and Tariff Rates

All the policies discussed in the previous sections in this chapter have some effect on horticultural imports, whether the quantity imported is large or small. It is, however, difficult to quantify the real effects because of the complicated implementation and uncertain effectiveness of policies. Quarantine regulations are especially difficult to assess quantitatively without extensive research on technical aspects. To evaluate policy within the framework of this study, an effort is made to capture the effects of reductions in distribution costs and tariff rates.

The distribution costs can be reduced by introducing more efficient marketing channels; supermarkets could be increased by abolishing the Large Retail Store Law, for example. As seen in Table 22, the retail costs of large shops and supermarkets are about 20 percent less than those of ordinary small shops in both vegetable and fruit sales. The ratio of sales in small shops to the total sales is not known, but it is assumed to be about 50 percent, judging from the previous discussion on fresh vegetable sales. Therefore, a 10 percent decline is expected in prices of horticultural products at retail levels if all retail shops could make their sales operations as efficient through competition as the supermarkets currently do.

The ratio of the distribution cost to the retail price is 57 percent, on average, for the six commodities reported in Table 21. Thus, the price decline of 10 percent at the retail level has the same effect on imports because the demand schedules at the port are shifted upward by 5.7 percent along the price axis. Similarly, an import tariff reduction shifts the import demand schedule upward by the same percentage as the tariff rate.

Therefore, if the supply of horticultural imports is horizontal at current c.i.f. price levels for the quantity range under consideration, how the reductions in distribution costs and tariff rates would affect the imports can be assessed by using the estimated parameters of import demand equations. The reductions in distribution costs and import tariffs apply uniformly to all the foreign suppliers of the commodity, so that the effects on the imports are calculated with the coefficient of the import price variable ($_1$) in the first-stage import demand equation (11), multiplied by the coefficient of the import expenditure variable ($_i$) in the trade-flow equation (7).

The effects of reducing distribution costs by 5.7 percent and eliminating tariffs on horticultural imports are calculated in Table 23. Because the estimated coefficients of the import price variable for onions and green beans have wrong signs, those commodities are omitted from the table. The effects of distribution cost reduction are proportional to the magnitude of the multiplied demand parameters. Among the trade flows from developing countries, reduction of the distribution costs would be beneficial for cut flowers and nonpickled ginger from Taiwan, cut flowers and canned bamboo shoots from Thailand, canned bamboo shoots from China, and mangoes from Mexico, all of which would increase by more than 10 percent. The effects of reducing tariffs to zero depend on the current tariff rates as well as the demand parameters. Tariff reductions would increase imports substantially of canned bamboo shoots and frozen pineapple from Thailand, of canned bamboo shoots from China, of fresh pineapple from Taiwan and the Philippines, and of kiwifruit from New Zealand, all of which would increase by more than 20 percent.

It is noteworthy that neither reduction of the distribution cost nor the tariff would affect imports of bananas from the Philippines. This results from the negative but insignificant estimate of the import expenditure coefficient, which is therefore set at zero in this calculation. Reduction of the distribution cost and the tariff would increase the total imports of bananas but not imports from the Philippines as long as the relative prices among the suppliers remain the same. The only way for the Philippines to increase banana exports to Japan would be to reduce the price relative to other suppliers' prices, unless they rely on nonprice factors such as sales promotion activities. The same applies to canned bamboo shoots from Taiwan.

The sum of the effects of the distribution costs and the tariff rate reductions varies by commodity and by country. Thailand would benefit from sharp export increases in canned bamboo shoots and frozen pineapple of nearly 50 percent each, if the distribution costs and the tariff rates were reduced simultaneously. The sum of the effects on the Philippines and Taiwan for fresh pineapple, on China for canned bamboo shoots, and on New Zealand for kiwifruit would also be great, with increases ranging from 30-40 percent. On the other hand, the import demand for dried bamboo shoots, pickled ginger, and canned pineapple would not be affected much by such policy changes.

Table 23—Effects of reduction in domestic distribution costs and import tariff rates on Japanese horticultural imports, as a percent of current imports

Commodity/ Country of Origin	Distribution Cost Reduction of 5.7 Percent	Tariff Rate Reduction to 0 Percent	Sum of the Effects
		(percent)	
Cut flowers			
Taiwan	16.1	0.0	16.1
Thailand	12.5	0.0	12.5
Netherlands	19.8	0.0	19.8
Bamboo shoots, dried			
Taiwan	0.4	0.5	1.0
China	0.2	0.3	0.6
Bamboo shoots, canned			
Taiwan	0.0	0.0	0.0
Thailand	13.2	36.9	50.1
China	10.5	29.5	39.9
Ginger, nonpickled			
Taiwan	17.2	0.0	17.2
Thailand	8.6	0.0	8.6
China	0.5	0.0	0.5
Ginger, pickled			
Taiwan	0.1	0.2	0.3
Thailand	0.4	1.0	1.3
Bananas			
Taiwan	5.1	12.8	17.9
Philippines	0.0	0.0	0.0
Mangoes			
Philippines	3.5	2.4	5.9
Mexico	11.4	8.0	19.4
Avocados			
Mexico	6.2	4.4	10.6
United States	10.1	7.1	17.2
Kiwifruit			
New Zealand	17.0	23.9	40.9
Pineapple, fresh			
Taiwan	8.1	28.3	36.4
Philippines	6.8	23.8	30.6
Pineapple, frozen			
Taiwan	0.6	3.0	3.7
Thailand	7.9	39.0	46.9
Pineapple, canned			
Taiwan	0.1	0.3	0.3
Philippines	0.0	0.2	0.2
Thailand	0.0	0.2	0.3

7

INTERNATIONAL TRANSPORTATION AND PRICE DETERMINATION

International Price Linkage

In the previous chapter, the importance of domestic distribution costs was recognized. How do costs affect international distribution? The international price linkage is examined by looking at the relationship between the export price and import price of the same commodity. However, because the classification of trade statistics differs by country, some export prices corresponding to import prices of the trade flows in this study are not available. Using the foreign trade statistics of Taiwan, Thailand, and the Philippines, export price data for 16 trade flows are collected and compared with corresponding Japanese import prices (Table 24).

The differences between import prices and export prices are usually transportation costs and marketing margins in international shipping. The ratio of export price to import price differs widely by commodity and by origin. For cut flowers, export prices are not much different in Taiwan than in Thailand, but on arrival in Japan, there is a wide gap between the two prices. This is caused by the difference in means of transportation: Taiwan ships their cut flowers to Japan by boat, whereas Thailand uses air cargo to ship their orchids. In general, the ratio of export price to import price is smaller for the products from Taiwan, reflecting its shorter distance from Japan.

The ratio of export price to import price is just 30 percent for Philippine bananas and pineapple, which means that Japan pays 70 percent of banana and pineapple prices to international distributers and only 30 percent is received by Philippine exporters. The ratio for Taiwan bananas and pineapple is almost reversed. The difference in distribution costs between Taiwan and the Philippines is attributed partly to the difference in distance from Japan. But it may also be attributed to the difference in organization of the fruit industry in the two countries. In the Philippines, the banana and pineapple industries are concentrated in a handful of multinational corporations, which operate through contracts with large plantations, whereas in Taiwan the banana and pineapple industries consist of many small growers. The multinational corporations in the Philippines are vertically integrated with international shipping and transportation companies. For example, the Dole Company in the Philippines sells its products to its mother company, Castle and Cook, which manages the international transportation and shipping arrangements. Then the products are sold to Japan's contracted import trader, Chu-Ito Company, which is one of a handful of trading companies in Japan that imports fruits from the Philippines. In such a vertical integration, the export price is simply a booking charge on transactions within the corporation group and can be set to maximize the total profit of the group rather than to reflect the

Table 24—Export and import prices of selected horticultural products imported to Japan, 1987-89 average

Commodity/ Country of Origin	F.O.B. Price[a]	C.I.F. Price[b]	F.O.B./C.I.F.
	(US cents/kilogram)		
Cut flowers			
Taiwan	201.8	277.6	0.727
Thailand	234.5	885.3	0.265
Onion			
Taiwan	29.7	34.2	0.868
Bamboo shoots, canned			
Taiwan	97.6	125.1	0.781
Thailand	58.4	88.0	0.664
Ginger			
Taiwan (pickled ginger)	88.0	88.3	0.996
Thailand	59.9	79.1	0.757
Green beans			
Thailand	45.4	48.6	0.936
Bananas			
Taiwan	48.2	66.9	0.720
Philippines	15.8	51.0	0.309
Mangoes			
Philippines	138.4	236.8	0.585
Pineapple, fresh			
Taiwan	70.5	90.6	0.777
Philippines	14.2	47.2	0.301
Pineapple, canned			
Taiwan	92.0	113.5	0.810
Philippines	53.9	109.8	0.491
Thailand	83.1	92.4	0.899

Sources: Japan Tariff Association, *Japan Exports and Imports (Commodity by Country)* (Tokyo: JTA, various years); Philippines, National Statistics Office, *Foreign Trade Statistics of the Philippines* (Manila: PNSO, various years); Republic of China Statistical Department, *Monthly Statistics of Trade* (Taipei: ROCSD, various years); Thailand, Finance Ministry, *Foreign Trade Statistics of Thailand* (Bangkok: TFM, various years).

Note: For Thailand and the Philippines, the 1986-88 average is used.

[a] The f.o.b. prices are the prices of exports in the countries exporting to Japan.

[b] The c.i.f. prices are the prices of imports upon entry into Japan.

marginal cost in production. The multinational corporations can transfer the pricing mechanism from one section to another within the integrated organization. Therefore, the difference in the export prices of bananas and pineapple between the Philippines and Taiwan may reflect a difference in industrial organization in addition to a difference in production costs.

Four factors affect the differences between import prices and export prices. First is the markup or marketing margin, which is part of the business of international distribution. Second is the transportation cost, which is determined by the distance from Japan. Third is the cost associated with the different treatment required in shipping the various commodities. Fourth are the factors specific to different countries, including differences in industrial organization and infrastructure. The effects of such factors are roughly captured by a regression model of the following relationship between import and export prices:

$$\ln PM_{ij} = \alpha \ln PX_{ij} + \beta_i DD_i + \gamma_j DC_j , \quad (16)$$

where PM_{ij} is the c.i.f. import price and PX_{ij} is the f.o.b. export price of commodity j from country i expressed in U.S. cents per kilogram; DD_i is the distance from country i to Japan; and DC_j is a dummy variable representing a specific cost factor to commodity j.[31] If the markup or marketing margin is a constant ratio to the export price, α is expected to be unity and γ_j consists of the common markup ratio and the commodity-specific cost effect. β_i also consists of two parts: the common transportation cost factor associated with distance and the country-specific factor. Therefore, the estimated coefficients of β_i and γ_j are subject to the test for equality. If there is a significant difference among them, it is attributed to either a country or commodity-specific factor.

The regression model for international price linkages expressed in equation (16) is applied to pooled data of 238 observations on import prices and export prices for the 16 trade flows over time. The data on import prices were obtained from the Japan Tariff Association, *Japan Exports and Imports* (various years); and other data from the Republic of China Statistical Department, *Monthly Statistics of Trade* (various years); Finance Ministry of Thailand, *Foreign Trade Statistics of Thailand* (various years); and the Philippine National Statistics Office, *Foreign Trade Statistics of the Philippines* (various years). The distance from Japan is taken from airline route mileage from Narita to Taipei, Bangkok, and Manila for Taiwan, Thailand, and the Philippines, respectively.

The ordinary least squares method (OLS) is used to obtain the regression results (Table 25). First, f.o.b. export prices are significantly correlated to c.i.f. import prices, but the coefficient of the f.o.b. export price variable is about 0.9—statistically less than unity with a 1 percent significance level. The changes in export prices are not perfectly transmitted to import price changes; about 10 percent are absorbed in the international distribution. In other words, the market margins seem to be adjusted through export price changes rather than strictly by taking a fixed ratio.

The coefficients of the distance variable show interesting results. The differences in the estimated coefficients by origin reveal some country-specific factors beyond the distance effect in the international distribution. The joint equality of all three coefficients of β_i and any pairwise equality among the coefficients are rejected. The most costly transportation per mile is for the products from the Philippines and the least is for the products from Thailand; Taiwan is positioned in the middle. This order of effectiveness of country factors may reflect efficiencies in the transportation industry by country. But the differences in exporters also seem to affect the order. The multinational corporations of the Philippines are integrated with international transportation. Taiwan exports horticultural products mainly through agricultural cooperatives that monopolize the export business, such as the Taiwan Fruit Marketing Cooperative, and may be more interested in stable transportation arrangements than in cost efficiencies. Thailand's exporters,

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[31] DDj takes the value of the distance from country i to Japan for the products from country i and a value of zero otherwise. DCj takes a value of one for the price of commodity j and a value of zero otherwise.

Table 25—Results of regression of Japan's c.i.f. import prices of selected horticultural products on f.o.b. export prices, with distance and commodity dummies

Variable	Coefficient	t-Value
F.o.b. export price	0.8948**	30.31
Distance from		
Taiwan	0.3073**	3.72
Thailand	0.1950**	5.15
Philippines	0.5067**	10.33
Commodity dummy		
Cut flowers	0.9184**	11.85
Bamboo shoots	0.1369*	2.40
Ginger	0.1190	1.93
Bananas	0.1805**	3.05
Mangoes	0.2033	1.84
Pineapple, fresh	0.5489**	8.72
Pineapple, canned	0.0902	1.54

Notes: The number of observations is 238. $\bar{R}^2$, the adjusted coefficient of determination, is 0.959. The standard error of estimation is 0.208.

*Significant at the 5 percent level.

**Significant at the 1 percent level.

however, are relatively small and tend to minimize the transportation cost by seeking the lowest rates.

The coefficients of the commodity dummies represent specific costs associated with special treatment required for shipping each commodity. Note that the dummy variable for green beans is excluded from the regression to avoid singularity of the cross-product matrix in the regression procedure. Therefore, the coefficient for each commodity indicates the difference from that of green beans. Because of their delicacy, cut flowers need special handling in shipping and therefore show a large and highly significant coefficient. Fresh pineapple, bananas, and bamboo shoots, whose coefficients are all significant at least at the 5 percent level, all require costly shipping procedures regardless of the origin of the products. Shipping of ginger, mangoes, and canned pineapple is not significantly costly compared with green beans, as shown by their small coefficients with low t-values.

Price Transmission by Trade Flow

The regression analysis using pooled data gives useful information on the structure of the international distribution system. However, it is necessary to investigate price relations by trade flow if the import demand analysis is to be connected to supply conditions in exporting countries. Price relations should be examined between import prices in the importer's currency and export prices in the exporter's currency because decisionmaking in demand and supply depends on price variables expressed in their own currencies. Therefore, the exchange rate is included as another explanatory variable in the price linkage, and the transmissibility is examined for two factors: export price transmissions and exchange rate transmissions.[32] For this purpose, the following price transmission equations are estimated for each of the 16 trade flows listed in Table 24:

$$\ln PM_{ij} = \alpha_{ij} + \beta_{ij}\ln PX_{ij} + \gamma_{ij}\ln EX_i , \qquad (17)$$

where PM_{ij} is the import price in the importer's currency and PX_{ij} is the export price in the exporter's currency of commodity j from country i, and EX_i is the exchange rate for the importer's currency per unit of the exporter's currency.

The results of the estimated transmission equations are presented in Table 26. Most of the coefficients are significantly different from zero. However, if the price transmission is perfect, the coefficients of both the export price variable and exchange rate variable are expected to be unity. Therefore, a joint hypothesis of unity for $\beta_{ij} = \gamma_{ij} = 1$ is first tested on each trade flow. Only 7 of the 16 trade flows do not reject the hypothesis at the 10 percent level. These include the trade flows for onions, canned bamboo shoots, ginger, bananas, and canned pineapple, all from Taiwan, ginger from Thailand, and mangoes from the Philippines. All other trade flows reject the joint unity hypothesis, indicating that either the export price or exchange rate changes or both are not being transmitted to import prices well.

To identify the reason for the reduced transmissibility of those trade flows, individual coefficients of the export price and exchange rate variables are tested if either is significantly different from unity. The export price coefficients are significantly less than unity at least at the 10 percent level for cut flowers, green beans, and canned pineapple from Thailand and for fresh and canned pineapple from the Philippines. The export price coefficients represent the sensitivity of import price changes to export price changes when the exchange rate is fixed. Therefore, if the coefficient is significantly less than unity, it means that the export price changes are partly absorbed in the process of international distribution. During the estimation period, all export prices of the commodities whose coefficients are significantly less than unity, except cut flowers, increased in the exporter's currency, but such increases in export prices were partly offset by cost reductions in either international transportation or declines in market margin or both. In the case of cut flowers from Thailand, export price changes were not transmitted at all—the coefficient is not statistically different from zero: the price changes in Thailand were mostly absorbed when the cut flowers arrived in Japan. This happened because the dominant factor in the import price of cut flowers from Thailand is the cost of transporting the flowers by air cargo, which fluctuates over time. Therefore, import price changes are not directly correlated to export price changes in cut flowers from Thailand.[33]

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[32] Presumably, import price changes would also reflect changes in transport costs. In preliminary regressions, a transport cost factor was introduced as an explanatory variable expressed in the ratio of total import values to total import values in Japan, representing an overall transportation cost change. But it did not result in significant coefficients for most trade flows, and the variable was omitted in the final regressions.

[33] Therefore, the transmission equation (17) is misspecified for cut flowers from Thailand because it excludes an important variable of air transportation cost. Data of transport cost by commodity are required for further investigations.

Table 26—Estimated transmission equations of Japan's import prices for selected horticultural products

Commodity/ Country of Origin	Variables to Be Transmitted			
	Export Price	Exchange Rate	Constant	$\bar{R}^2$
Cut flowers				
Taiwan, 1974-89	0.900	1.398	0.701	0.628
	(3.27)	(5.19)	(0.25)	
Thailand, 1975-88	−0.124	0.729	11.527	0.875
	(-0.96)	(9.55)	(10.33)	
Onion				
Taiwan, 1980-89[a]	0.904	0.867	0.608	0.971
	(17.38)	(3.71)	(1.30)	
Bamboo shoots, canned				
Taiwan, 1980-89	0.926	0.778	1.148	0.923
	(9.29)	(8.61)	(1.32)	
Thailand, 1974-88	0.688	0.438	3.651	0.638
	(4.21)	(2.00)	(2.35)	
Ginger				
Taiwan, 1980-89 (pickled ginger)	0.869	0.955	1.086	0.924
	(10.09)	(7.49)	(1.37)	
Thailand, 1977-88	1.058	1.014	−0.177	0.865
	(3.65)	(8.34)	(0.08)	
Green beans				
Thailand, 1970-88	0.942	0.954	0.568	0.992
	(48.56)	(31.71)	(3.10)	
Bananas				
Taiwan, 1974-89	1.014	0.942	0.324	0.884
	(10.44)	(5.55)	(0.35)	
Philippines, 1969-88[a]	0.985	0.681	1.882	0.916
	(6.69)	(4.52)	(1.66)	
Mangoes				
Philippines, 1980-88[a]	0.837	1.042	1.794	0.862
	(3.67)	(5.23)	(0.82)	
Pineapple, fresh				
Taiwan, 1980-89	0.751	1.188	1.879	0.677
	(3.52)	(1.76)	(0.72)	
Philippines, 1970-88	0.475	0.598	4.945	0.739
	(7.25)	(6.81)	(8.87)	
Pineapple, canned				
Taiwan, 1980-89	0.658	1.079	2.830	0.837
	(3.43)	(5.82)	(1.84)	
Philippines, 1970-88[a]	0.451	0.814	5.127	0.914
	(2.88)	(5.93)	(3.80)	
Thailand, 1970-88	0.907	0.931	0.958	0.962
	(21.13)	(14.76)	(2.20)	

Notes: $\bar{R}^2$ is the adjusted coefficient of determination. The years represent the estimation periods. t-values are in parentheses.

[a] Estimated with a first-order autocorrelation correction.

Next, the transmissibility of exchange rate changes is examined. The estimated coefficients of the exchange rate variable are significantly less than unity for the trade flows of cut flowers and bamboo shoots from Thailand, bamboo shoots from Taiwan, and banana and fresh pineapple from the Philippines. In these trade flows, exchange rate changes transmit poorly to import prices in Japanese yen. During the rapid appreciation of the Japanese yen, which should have resulted in cheaper imported goods in Japanese markets, some consumers in Japan doubted whether they were benefiting from the strong purchasing power of the yen, since the prices of these commodities did not change much.

If import traders have enough market power to set prices on imported products, they do not necessarily transmit exchange rate changes. If, in particular, traders believe that demand for their imported products is very inelastic to downward price changes in domestic markets, they tend not to transmit exchange rate appreciations, which lower domestic prices and decrease their sales volume. Bananas and pineapple are an example because these fruits are imported by just a handful of large traders. More detailed information is needed on the market structures for cut flowers and bamboo shoots. If sales contracts are made in Japanese yen and if the exchange rate changes during the shipment, the recorded import price in Japan does not change, whereas the export price is recorded at an old exchange rate in the exporting country, which results in less transmissibility of exchange rate changes. Another possible reason for the low transmissibility is that traders on both the export and import sides may use exchange rates different from the market rates in their business to avoid the risk of rapid fluctuation in the market rate.

Export Price Determination

The examination of the growth of horticultural trade in Japan's market has so far mainly emphasized demand factors. Needless to say, supply-side conditions are equally important. However, data on production and distribution structures in exporting countries are extremely limited for horticultural commodities, which are still considered minor agricultural products. In dealing with supply-side conditions, the determinants of export prices are explored assuming a production function with constant returns to scale.

First, the aggregate production function for a horticultural commodity is considered in the following form:

$$X = A(t)\,F(L,K), \tag{18}$$

where X is output of the product, L and K are labor and capital inputs, respectively, and A(t) is an exogenous shifter, which changes over time and represents productivity increases due to technological progress and other factors. The function F is assumed to be linearly homogeneous.

The cost of production for output X is the sum of labor and capital costs expressed as follows:

$$cX = wL + rK, \tag{19}$$

where c is the unit cost of production, w is the wage rate, and r is capital rental.

Taking the total differential of equation (18) and substituting for it the total differential of equation (19), with assumptions of profit maximization and perfect competition, yields the following results.

$$G(c) = SwG(w) + (1 - Sw)G(r) - G(A), \tag{20}$$

where Sw is the share of labor in the total cost (wL/cX) and G denotes percentage changes of the variable in parentheses following G.

Since the production function (18) is linearly homogeneous, with constant returns to scale, the change in output price is equal to the change in the unit cost. Therefore, if there is no distortion in the domestic distribution, the rate of change in the export price, G(PX), is determined by the rate of change in the unit cost of production:

$$G(PX) = G(c). \tag{21}$$

Therefore, the export price changes can be expressed as a linear combination of wage rate changes and capital rental changes with the productivity improvement factor.

Using this framework of price determination, the factors that caused the export price changes in Taiwan, Thailand, and the Philippines during 1979-81 to 1987-89 are examined. To decompose export price changes according to equations (20) and (21), data on the labor share by commodity, the agricultural wage rate, and agricultural capital rental by country are required.

Data on labor shares in total production costs are available for several horticultural products in Taiwan. Labor costs in Taiwan for commodities related to this study are shown in Table 27, and labor shares are calculated as ratios of the total production cost.[34] Taiwan's labor share data are also used for products of Thailand and the Philippines because no data on labor shares are available for them. This means that the production function for each commodity is assumed to be common to all three exporting regions. It is specified as Cobb-Douglas, with unity elasticity of substitution between labor and capital inputs.

Data on agricultural wages and capital rental are not available for any of the three regions. In considering alternative variables that might show change rates similar to the agricultural wage rate and capital rental, the growth rates of agricultural output per agricultural laborer and the general (consumer) price index are chosen. The agricultural wage rate is closely correlated to the labor productivity expressed in output per laborer. For agricultural capital rental, the price index of agricultural inputs is desirable but not available for those regions. The data on agricultural output per agricultural laborer and the consumer price index were obtained from the U.S. Department of Agriculture (1990b) for Thailand and the Philippines, and from the Council for Economic Planning and Development (1990) for Taiwan.

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[34] For cut flowers, labor share of chrysanthemums is used, and for canned bamboo shoots and pickled ginger, labor share in processing is assumed to be the same as in farm production of bamboo shoots and ginger, respectively.

Table 27—Labor cost in production of selected horticultural commodities, Taiwan, 1989

Commodity	Labor Cost	Total Cost	Labor Share
	(NT$100/hectare)		(percent)
Chrysanthemums	2,863	5,305	54.0
Onions	1,193	1,798	66.4
Bamboo shoots	1,353	1,859	72.8
Ginger[a]	1,677	2,389	70.2
Green beans	325	496	65.5
Bananas	1,490	2,695	55.3
Mangoes	1,201	2,189	54.9
Pineapple	1,123	2,860	39.3

Source: Taiwan, Provincial Department of Agriculture and Forestry, *Report on Production Cost Survey for Agricultural Products in Taiwan* (Taipei: TPDAF, 1990).

[a] 1988 data.

The results of decomposition of export price changes for selected horticultural products in Taiwan, Thailand, and the Philippines are shown in Table 28. Reflecting recent increases in Taiwan's agricultural output per laborer, expressed in U.S. dollars, which may partly be attributed to recent appreciation in the New Taiwan dollar, Taiwan's labor cost changes played a substantial role in increasing export prices of all the commodities listed. For Thailand and the Philippines, however, labor cost changes exerted little pressure on export prices during the period of investigation. As shown in Table 27, most horticultural commodities are relatively labor-intensive in production, so that capital cost changes play a relatively minor role in export price changes.

Theoretically, the last term of the decomposition [$-G(A)$] represents technological progress, which works to reduce export prices. Therefore, the numbers in the last column in Table 28 are expected to be all negative, but only 6 export prices out of 13 recorded negative numbers. In reality, the last term is a residual after subtracting labor cost changes and capital cost changes from the export price changes. Therefore, all other effects are included in this term. Nonetheless, cut flowers, ginger, and green beans in Thailand show large negative numbers in the last term, and technological progress is likely to have played an important role in reducing export prices of these products. Meanwhile, all the tropical fruits—bananas, mangoes, and pineapple—recorded relatively large positive numbers. For these fruits, there must be factors that raise export prices above the offsetting effects of technological progress, if any.

The results of the decomposition of export prices serve as a reminder of the importance of domestic distribution costs which, as indicated in the previous chapter, account for 50-70 percent of retail prices in Japan. Even the costs of distribution from producers to wholesale markets account for 30-40 percent of the wholesale prices. The importance of domestic distribution costs can also be applied to exporting countries. It is reported, for example, that marketing margins of exported *longans*, a fruit similar to litchis, in Thailand accounted for 20-40 percent of the export price in 1982 (TDRI 1987). Therefore, it is equally important to

Table 28—Composition of f.o.b. export price changes for selected horticultural products, 1979-81 to 1987-89

Commodity/ Country of Origin	Export Price Change G(PX)	Labor Cost Change SwG(w)	Capital Cost Change (1-Sw)G(r)	Other Factor Change -G(A)
		(percent)		
Cut flowers				
Taiwan	3.96	3.63	1.17	-0.84
Thailand	-8.08	0.73	0.66	-9.47
Onions				
Taiwan	5.12	4.47	0.85	-0.20
Bamboo shoots, canned				
Taiwan	5.36	4.90	0.69	-0.23
Thailand	6.50	0.98	0.39	5.13
Ginger				
Taiwan (pickled ginger)	7.17	4.73	0.75	1.69
Thailand	-1.08	0.95	0.43	-2.46
Green beans				
Thailand	-1.36	0.88	0.50	-2.74
Bananas				
Taiwan	7.68	3.72	1.13	2.83
Philippines	3.26	0.03	0.17	3.06
Mangoes				
Philippines	2.58	0.03	0.18	2.38
Pineapple, fresh				
Taiwan	19.90	2.64	1.54	15.72
Philippines	5.93	0.02	0.24	5.68

Notes: F.o b. export prices are unit values in US cents per kilogram at the country of origin. Change rates are compounded rates per year for 1980-82 to 1987-89 for Taiwan and for 1979-81 to 1986-88 for Thailand and the Philippines.

production analysis to investigate the distribution costs and the mechanism of price transmission from farmgate to market in exporting countries. It is quite possible that changes in domestic distribution costs and other related factors skewed the results of export price change decomposition in Table 28.

8

CONCLUSIONS

Horticultural trade is one of the most urgent items on the agricultural trade research agenda because the accumulation of knowledge is so small, despite its increasing importance. Because Japan is an example of a rapidly growing market, this report has emphasized the trade flows of horticultural products from developing countries to Japan.

Japan is a promising market for foreign suppliers of horticultural products, not only because volume of imports is increasing but also because the range of horticultural commodities imported is expanding. Japan's rapid increases in horticultural imports are supported by technological improvements in international transportation and wider knowledge of foreign products as a result of increased international travel and improved communication systems. The market for horticultural imports is very dynamic, changing from year to year. The commodities selected for research in this report are relatively traditional horticultural commodities.

In searching for the reasons behind the rapid growth in Japan's imports of horticultural products, an import demand analysis based on the theory of product differentiation by country of origin was the starting point. The demand analysis aimed at determining the importance of price factors showed that imports in many trade flows are extremely sensitive to both price and income changes. This is evidence that the market for horticultural imports in Japan is very competitive and that price factors play an important role in determining the competitiveness of the suppliers.

The results of the import demand analysis have many implications for nonprice factors as well. Unlike trade-flow equations, which are usually price and income sensitive, the first-stage demand equations by commodity resulted in statistically significant price coefficients for only 8 commodities and income coefficients for 6 commodities, out of 14 in the study. It appears, therefore, that price factors are not of much importance in determining Japan's import demand for vegetables, except nonpickled ginger. In other words, if the suppliers of a price-inelastic commodity as a whole are anxious to expand exports and not just to gain at each other's expense, then nonprice factors, such as quarantine regulations, market structure for imports, and sales promotion by exporters, appear to be more important.

However, given the overall import demand for a commodity, the share of each supplier is influenced to a much greater extent than the aggregate demand by the price competitiveness of the suppliers. The estimated large price and income elasticities for trade flows shed light on why many developing countries are interested in horticultural exports and justify diversification policies that emphasize horticulture. Large own-price elasticities of trade flows in particular promise to increase the suppliers' export earnings if they can reduce their prices compared with other suppliers. However, it is important to recognize that the import price declines that stimulated the growth of horticultural imports in Japan in the 1980s were mainly the result of exchange rate changes, since the Japanese yen appreciated by 5.9 percent a year during the period from 1979-81 to 1987-89. Not many trade flows recorded price declines beyond the exchange rate changes during that period. Unless rapid appreciation of the Japanese yen is expected, price declines will have to be realized by reducing costs in production, marketing, and distribution, in order for export growth like that of the 1980s to continue.

To reduce costs, developing countries should take advantage of abundant labor relative to capital and land because horticultural production is generally labor-intensive. However, the cost advantage at the farm production level determines only a part of the final price. Examination of international price linkages shows that some export prices account for only 30 percent or so of the corresponding import prices. If the domestic distribution costs in both importing and exporting countries are taken into account, the weight of production costs in the final consumer price becomes even smaller. For example, domestic distribution costs of bananas from the Philippines account for two-thirds of the retail price in Japan, and international distribution costs amount to more than two-thirds of Japan's import price. Therefore, the price paid for bananas at Philippine ports is just 10 percent of the retail price paid by Japanese consumers; 90 percent of the price goes to distribution costs. Therefore, the search for ways to reduce costs and increase efficiencies in both domestic and international distribution should be intensified. For this reason, the structure of distribution systems, the determinants of transportation costs, and the pricing mechanisms at each stage of distribution must be investigated carefully.

In pricing horticultural commodities, such postharvest activities as processing, distributing, marketing, and transporting products all benefit from economies of scale, largely from the use of public infrastructure like airports, docking facilities, and fumigation plants. Improving public infrastructure, therefore, is key to enabling developing countries to pursue their potential comparative advantage in horticulture and to strengthen their competitiveness in the world market. Success in horticultural trade depends on price mechanisms that work well without too much government intervention. But governments have an important role to play in providing public goods, which are difficult for the private sector to supply because of the "free-rider" problem. Governments of importing countries like Japan may also contribute to improving the infrastructure in developing countries, which would result in import price declines and benefit consumers in importing countries as well.

Of course, policy changes in importing countries that aim to reform domestic distribution systems and to reduce barriers against horticultural imports would greatly benefit developing countries. For example, the combined effects of reducing distribution costs by abolishing the Large Retail Store Law and changing tariff rates to zero in Japan would increase exports of some commodities from developing countries by 30-50 percent.

Government assistance should also be directed toward solving the technical problems posed by Japan's quarantine regulations. The phytosanitary regulation issues themselves have to be harmonized in international settings such as the GATT negotiations, but it is taking a long time to reach agreements in this area. One way for developing countries to export more horticultural products is to satisfy conditions so that bans on commodities can be lifted. Importing countries can assist by collaborating on research to develop better technologies for pest extermination and crop disinfection. The number of commodities and varieties that are permitted to be imported into Japan with conditions has been increasing in recent years.

Although Japan is a growing market for a number of horticultural products, the share of Japanese imports from the developing world has been decreasing. Developing countries should pay special attention to the following observations. Developing-country exports are heavily concentrated in mature horticultural markets such as bananas and pineapple. In branching into new horticultural products, developing countries are probably less able to meet the strict phytosanitary standards than developed countries. The importance of phytosanitary barriers means that technology and capital are assets in exporting to Japan. While some of these barriers may be trade barriers that will disappear, most are probably defensible and nonnegotiable. Hence, low labor costs alone may not allow developing countries access to the Japanese market. Policymakers in developing countries should take into account these rather gloomy aspects of horticultural trade and actively pursue policies that will enable their countries to take advantage of existing export opportunities.

Research on horticultural trade is still at an infant stage, and this study is just a stepping-stone for further research. The approach used in this report to study import demand for horticultural products is not based on a complete demand system, because of the failure of some data to fit. The parameters estimated here represent composite characteristics of consumer demand and trader behavior. It is certainly desirable to build a formal model that expresses consistently the import behavior of traders, consumer preferences, and the structure of industrial organization of trade. The approach adopted here is a compromise with reality, given the complicated structure of horticultural imports.

For better understanding of the current conditions and future prospects in horticultural markets, it is important to collect detailed statistics on prices, quantities of production, consumption, imports, exports, costs of production, and distribution in both exporting and importing countries. Horticultural products have been relatively neglected in both national and international statistics. If a significant push is to be made to increase the importance of horticultural exports of developing countries, much more information than is readily available today needs to be collected. This study of Japan's market needs to be compared with studies of other markets to derive meaningful implications.

APPENDIX:
SUPPLEMENTARY TABLES

Table 29—Ordinary least square estimates of first-stage demand equations for Japan's imports of cut flowers, onions, and bamboo shoots

Explanatory Variable	Cut Flowers	Onions	Bamboo Shoots	
			Dried	Canned
Estimation period	1969-89	1966-89	1965-89	1965-89
Constant	0.797	23.405	9.255	11.429
Constant dummy	...	-13.505	-4.747	...
		(-2.62)	(-4.78)	
Import price	-2.134	0.313	-0.070	-0.752
	(-7.02)	(0.846)	(-0.73)	(-2.04)
Slope dummy	...	...	...	...
Income	2.303	3.225	0.979	2.523
	(3.38)	(5.75)	(7.33)	(4.97)
Slope dummy	...	-3.666	-1.190	...
		(-2.77)	(-4.66)	
Price of substitutes[a]	4.363	-1.735	-0.378	-1.023
	(3.66)	(-1.48)	(-1.34)	(-1.17)
Slope dummy	...	4.708	...	...
		(2.16)		
Price of domestic products or imports of the same kind[b]	...	1.343	...	...
		(3.32)		
$\bar{R}^2$	0.991	0.891	0.771	0.903
Standard error of estimate	0.170	0.235	0.077	0.249
Durbin-Watson statistics	1.675	2.383	2.537	1.994
Period for dummies	...	1978-89	1977-89	...
F-value for dummies	...	11.11	14.77	...

Notes: The numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

[a] Prices of substitutes are from the cut flower price index for cut flowers and from the consumer vegetable price index for onions and bamboo shoots.

[b] Prices of domestic products or imports of the same kind are from doemstic market prices for onions.

Table 30—Ordinary least square estimates of first-stage demand equations for Japan's imports of ginger, green beans, kiwifruit, and avocados

Explanatory Variable	Ginger				
	Pickled	Nonpickled	Green Beans	Kiwifruit	Avocados
Estimation period	1970-89	1970-89	1965-89	1981-89	1979-89
Constant	17.609	29.234	2.896	-5.540	-4.167
Constant dummy	...	...	...	...	...
Import price	-0.020	-1.720	0.022	-2.746	-1.648
	(-0.09)	(-2.83)	(0.31)	(-8.97)	(-5.82)
Slope dummy	...	...	...	...	...
Income	2.116	2.659	0.368	1.765	0.994
	(3.36)	(1.25)	(2.45)	(1.12)	(0.78)
Slope dummy	...	...	...	...	...
Price of substitutes[a]	-0.801	0.288	0.281	1.072	-0.899
	(-1.12)	(0.12)	(0.78)	(1.34)	(-0.53)
Slope dummy	...	...	...	...	...
Price of domestic products or imports of the same kind[b]	0.206	3.137	...	1.612	...
	(1.15)	(4.30)		(2.99)	
$\bar{R}^2$	0.543	0.615	0.485	0.988	0.910
Standard error of estimate	0.157	0.533	0.100	0.095	0.224
Durbin-Watson statistics	1.567	1.598	2.376	2.395	1.219

Notes: The numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

[a] Prices of substitutes are from the consumer vegetable price index for ginger and green beans, and from the consumer fruit price index for kiwifruit and avocados.

[b] Prices of domestic products or imports of the same kind are from the domestic market price of kiwifruit; and the import price of nonpickled ginger is used for pickled and vice versa.

Table 31—Ordinary least square estimates for first-stage demand equations for Japan's imports of bananas, mangoes, and pineapple

Explanatory Variable			Pineapple		
	Bananas	Mangoes	Fresh	Frozen	Canned
Estimation period	1965–89	1980–89	1965–89	1973–89	1965–89
Constant	22.061	10.993	-13.513	89.155	28.101
Constant dummy	-17.588		16.003	-90.102	-16.113
	(-6.06)	. . .	(5.50)	(-5.38)	(-4.18)
Import price	0.275	-1.038	-2.365	2.394	1.957
	(1.96)	(-4.44)	(-6.94)	(3.65)	(3.08)
Slope dummy	-0.832	. . .	1.696	-2.873	-1.964
	(-4.16)		(5.40)	(-3.40)	(-3.98)
Income	2.068	3.546	-0.129	15.778	1.219
	(8.70)	(4.84)	(-0.28)	(7.46)	(2.04)
Slope dummy	-2.457	. . .	. . .	-16.797	. . .
	(-6.90)			(-6.05)	
Price of substitutes[a]	0.753	0.324	2.911	1.109	0.972
	(1.90)	(0.44)	(4.25)	(0.79)	(0.91)
Slope dummy	. . .	. . .	-2.442	. . .	. . .
			(-2.21)		
$\bar{R}^2$	0.895	0.977	0.972	0.771	0.859
Standard error of estimate	0.076	0.090	0.115	0.184	0.217
Durbin-Watson statistics	2.416	1.639	1.891	1.728	1.260
Period for dummies	1977-89	. . .	1979-89	1980-89	1975-89
F-value for dummies	54.30	. . .	17.21	14.74	25.06

Notes: The numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

[a] Prices of substitutes are from the consumer fruit price index for bananas, mangoes, and pineapple.

Table 32—Seemingly unrelated regression estimates of trade-flow equations for Japan's imports of cut flowers, 1972-89

Explanatory Variable	Taiwan	Thailand	Netherlands
Price			
Taiwan	-1.337 (-7.49)	0.916 (4.11)	. . .
Thailand	1.261 (6.61)	-1.650 (-4.89)	. . .
Netherlands	. . .	. . .	-2.743 (-8.44)
Rest of world	1.083 (2.31)	. . .	. . .
Import expenditure	1.322 (19.09)	1.032 (16.54)	1.624 (11.25)
Dummy, 1986-89	-0.602 (-2.73)	. . .	1.954 (4.02)
Constant	-4.083	-0.193	-6.366
$\bar{R}^2$	0.978	0.990	0.942
Standard error of estimate	0.227	0.193	0.741
Durbin-Watson statistics	0.888	1.621	1.249

Notes: Numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

Table 33—Seemingly unrelated regression estimates of trade-flow equations for Japan's imports of onions, 1970-89

Explanatory Variable	Taiwan	United States	New Zealand
Price			
Taiwan	0.678 (1.93)	. . .	1.526 (1.26)
United States	0.798 (1.62)	-2.191 (-2.69)	. . .
New Zealand	1.250 (2.16)	. . .	-1.292 (-0.69)
Import expenditure	0.259 (2.21)	1.165 (5.19)	1.781 (3.85)
Constant	4.873	-2.467	-8.324
$\bar{R}^2$	0.230	0.609	0.352
Standard error of estimate	0.296	0.549	1.168
Durbin-Watson statistics	2.153	2.711	1.669

Notes: Numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

Table 34—Seemingly unrelated regression estimates of trade-flow equations for Japan's imports of bamboo shoots, dried and canned, 1966-89

Explanatory Variable	Dried, 1966-89		Canned, 1973-89		
	Taiwan	China	Taiwan	China	Thailand
Price					
Taiwan	-2.755 (-26.71)	8.709 (2.75)	-2.673 (-3.17)	. . .	14.883 (1.62)
China	. . .	-0.705 (-1.72)	0.305 (1.59)	-2.090 (-4.49)	. . .
Thailand	. . .	. . .	. . .	. . .	-8.546 (-4.56)
Rest of world	. . .	0.250 (1.23)	0.182 (3.13)	. . .	. . .
Import expenditure	1.027 (24.44)	0.603 (0.63)	-0.036 (-0.21)	2.449 (5.28)	3.071 (2.24)
Constant	-0.115	-0.257	7.692	-13.203	-22.858
$\bar{R}^2$	0.995	0.763	0.452	0.838	0.534
Standard error of estimate	0.021	0.486	0.231	0.623	1.616
Durbin-Watson statistics	2.263	1.780	0.984	0.560	1.200
ρ^a	0.261	0.769	. . .	. . .	. . .

Notes: The numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

[a]First-lag correlation coefficient in the first-stage regression.

Table 35—Seemingly unrelated regression estimates of trade-flow equations for Japan's imports of ginger, pickled and nonpickled, 1973-89

Explanatory Variable	Pickled, 1978-89		Nonpickled, 1973-89		
	Taiwan	Thailand	Taiwan	Thailand	China
Price					
Taiwan	-7.897 (-9.73)	. . .	-1.558 (-6.43)	. . .	. . .
Thailand	. . .	-1.022 (-0.78)	0.508 (1.83)	-1.648 (-1.61)	. . .
China	. . .	. . .	. . .	. . .	-1.160 (-4.17)
Rest of world	. . .	. . .	0.503 (1.91)	. . .	. . .
Import expenditure	0.731 (2.43)	3.141 (9.09)	1.753 (15.38)	0.874 (2.22)	0.054 (0.53)
Constant	2.014	-6.894	-4.960	-4.952	1.413
$\bar{R}^2$	0.873	0.955	0.933	0.153	0.571
Standard error of estimate	0.217	0.234	0.371	1.232	0.323
Durbin-Watson statistics	1.734	2.620	1.471	1.703	2.394
ρ^a	. . .	0.616	. . .	. . .	0.662

Notes: The numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

[a]First-lag correlation coefficient in the first-stage regression.

Table 36—Seemingly unrelated regression estimates of trade-flow equations for Japan's imports of green beans, kiwifruit, and avocados, 1972-89

Explanatory Variable	Green Beans, 1972-89	Kiwifruit, 1981-89	Avocados, 1979-89	
	Thailand[a]	New Zealand[b]	Mexico	United States
Price				
Thailand	-2.053 (-2.65)	...	...	...
New Zealand	...	0.052 (0.09)	...	...
Mexico	...	...	-2.014 (-3.22)	0.455 (2.55)
United States	...	...	...	-0.354 (-1.49)
Import expenditure	1.070 (4.70)	1.086 (60.30)	0.662 (3.72)	1.077 (23.20)
Constant	-0.890	-0.757	0.168	-0.674
$\bar{R}^2$	0.409	0.999	0.715	0.974
Standard error of estimate	0.126	0.036	0.460	0.128
Durbin-Watson statistics	1.379	2.376	1.580	1.735
ρ[c]	0.933	...	...	...

Notes: The numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

[a] Single-equation estimates by the first-order autocorrelation correction method.

[b] Single-equation estimates by ordinary least squares.

[c] First-lag correlation coefficient.

Table 37—Seemingly unrelated regression estimates of trade-flow equations for Japan's imports of bananas and mangoes, 1966-89

Explanatory Variable	Bananas, 1966-89		Mangoes, 1980-89	
	Taiwan	Philippines	Philippines	Mexico
Price				
Taiwan	-2.029 (-5.22)	...	...	...
Philippines	...	-4.448 (-1.42)	-1.931 (-8.92)	...
Mexico	...	...	...	-2.434 (-8.43)
Import expenditure	1.603 (4.87)	-0.765 (-0.73)	0.588 (4.54)	1.924 (4.93)
Dummy, 1969-89	-1.399 (-6.42)	3.687 (6.88)	...	...
Constant	-6.843	4.362	0.344	-0.797
$\bar{R}^2$	0.810	0.962	0.986	0.573
Standard error of estimate	0.297	0.480	0.084	0.253
Durbin-Watson statistics	1.999	1.504	1.226	1.644
ρ[a]	...	0.717	0.871	0.902

Notes: Numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

[a] First-lag correlation coefficient in the first-stage regression.

Table 38—Seemingly unrelated regression estimates of trade-flow equations for Japan's imports of pineapple, fresh and frozen, 1966-89

Explanatory Variable	Fresh, 1966-89		Frozen, 1974-89	
	Taiwan	Philippines	Taiwan	Thailand
Price				
Taiwan	−0.365	. . .	−0.842	. . .
	(−0.40)		(−1.12)	
Philippines	. . .	−5.332	. . .	. . .
		(−7.04)		
Thailand	. . .	. . .	. . .	−4.096
				(−3.47)
Rest of world	. . .	. . .	. . .	1.278
				(2.06)
Import expenditures	2.115	1.777	0.227	2.908
	(3.73)	(8.96)	(0.36)	(7.36)
Constant	−0.869	−3.997	−0.147	−5.940
$\bar{R}^2$	0.818	0.965	0.860	0.926
Standard error of estimate	0.648	0.339	1.098	0.490
Durbin-Watson statistics	1.170	1.973	2.250	1.751
ρ^a	0.943	0.449	0.908	0.597

Notes: Numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

[a] First-lag correlation coefficient in the first-stage regression.

Table 39—Seemingly unrelated regression estimates of trade-flow equations for Japan's imports of canned pineapple, 1972-89

Explanatory Variable	Taiwan	Thailand	Philippines
Price			
Taiwan	−4.317	. . .	. . .
	(−4.05)		
Thailand	8.218	−0.700	. . .
	(3.31)	(−0.59)	
Philippines	. . .	. . .	−0.902
			(−1.07)
Rest of world	4.366	. . .	. . .
	(2.20)		
Import expenditure	1.349	1.013	0.918
	(4.32)	(5.79)	(10.45)
Constant	−3.399	−0.561	−0.244
$\bar{R}^2$	0.652	0.731	0.802
Standard error of estimate	0.457	0.234	0.107
Durbin-Watson statistics	1.790	2.160	2.520
ρ^a	. . .	0.588	0.447

Notes: Numbers in parentheses are student t-values. $\bar{R}^2$ is the coefficient of determination adjusted by the degree of freedom.

[a] First-lag correlation coefficient in the first-stage regression.

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R5620-1.34F 9/92

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LABOR IN THE RURAL HOUSEHOLD ECONOMY OF THE ZAIRIAN BASIN

Tshikala B. Tshibaka

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LABOR IN THE RURAL HOUSEHOLD ECONOMY OF THE ZAIRIAN BASIN

Tshikala B. Tshibaka

Research Report 90
International Food Policy Research Institute

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Library of Congress Cataloging-in-Publication Data

Tshibaka, Tskhikala B., 1949-
Labor in the rural household economy of the Zairian basin / Tshikala B. Tshibaka.
p. cm. — (Research report ; 90)
Includes bibliographical references.
ISBN 0-89629-093-X
1. Agricultural laborers—Zaire. 2. Household surveys—Zaire. 3. Farms, Small—Zaire. 4. Time management—Zaire. 5. Sexual division of labor—Zaire. I. Title. II. Series: Research report (International Food Policy Research Institute) ; 90.

HD1538.Z3T79 1992 92-23773
306.3'615'096751—dc20 CIP

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FOREWORD

The deterioration of the food sector in Sub-Saharan Africa, combined with rapid population growth and the degradation of the environment, continues to present a challenge to policymakers in both Africa and the donor community. The agricultural and other policies that have been followed have failed to reverse the trend. One reason for this failure has been lack of data on the workings of the rural household economy, which is the main food producer in the Sub-Saharan region.

This study attempts to address this gap by examining various aspects of labor in the rural household economy. It identifies main determinants of labor use and allocation, assesses factors that affect labor productivity, and makes some recommendations on how the productivity of labor can be enhanced in the farm sector. The need to increase the productivity of labor allocated to agriculture is central from the standpoint of both growth and equity. Labor input accounts for more than 70 percent of the agricultural output of Sub-Saharan Africa.

The study is conducted in the Zairian Basin, a rain forest zone that is among the least-studied areas of the developing world. Thus this research report by Tshikala B. Tshibaka represents a major contribution to our understanding of the rural household economy in this part of the world and provides useful information to policymakers.

The report is a follow-up study based on the survey that led to the publication of IFPRI Research Report 74 by the same author. That survey, conducted in collaboration with the Institut Facultaire des Sciences Agronomiques (IFA), Yangambi, Zaire, was partially funded by the International Development Research Centre of Canada (IDRC). IFPRI and IFA reiterate their gratitude to IDRC for its support.

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Washington, D.C.

ACKNOWLEDGMENTS

The data used for this study are taken from a survey undertaken during the 1982/83 crop year in collaboration with the Institut Facultaire des Sciences Agronomiques (IFA), Yangambi, Zaire. This effort was partially funded by the International Development Research Centre (IDRC) of Canada, to whom the author wishes to express his sincere appreciation.

The author is grateful to Raisuddin Ahmed for suggesting this analysis and to Just Faaland for his advice and comments. Stephen Vosti, Dayanatha Jha, and Behjat Hojjati gave thoughtful, constructive comments on the first draft that were helpful in revising the manuscript. Hojjati was also instrumental in data processing and analysis. The author also acknowledges the comments by anonymous reviewers.

1

SUMMARY

Most agricultural labor studies conducted in Sub-Saharan Africa have tended to concentrate on describing the division of labor, estimating the amount of labor input allocated to agriculture and to other household activities, examining the seasonality of labor time allocated to agriculture, and estimating the productivity of this resource and its contribution to agricultural output. In addition to these aspects, this study attempts to identify the key economic and other variables that affect the use and productivity of labor in the small-farm sector of the rural household economy, thus contributing to an understanding of the rural household economy in the Zairian Basin, one of the least-known areas of the developing world.

The 1982/83 survey on which the study is based indicates a clear gender division of household labor, with men relatively more involved in income-generating activities and women relatively more engaged in non-income-generating activities. Male household members spent about 24.3 percent of the potential 12 hours of daily working time on income-generating activities, of which 5.9 percent was expended on farming and 18.4 percent on nonfarming activities. Females allocated 19.8 percent of the potential working time to income-generating activities, of which 6.2 percent was devoted to farming and 13.6 percent to nonfarming activities. Of the 75.7 percent of potential male working time allocated to non-income-generating activities, 15.6 percent was used for domestic activities and 60.1 percent for sociocultural and leisure activities. Females allocated 80.2 percent of their potential working time to non-income-generating activities, of which 25.9 percent was for housework and 54.3 percent for sociocultural and leisure activities. Overall, household members allocated 6.1 percent of their potential working time to agriculture, 15.7 percent to nonagricultural income-generating activities, 21.3 percent to domestic activities, and 56.9 percent to sociocultural and leisure activities.

The allocation of labor time in the study area presents different seasonal patterns for men and women. However, it is important to emphasize that no male or female household member spent more than 50 percent of his or her available monthly time on income-generating (farming and nonfarming) activities during the entire year of the survey. This implies that the observed pattern of labor use does not suggest any seasonal labor shortages in the study area.

The analysis of the determinants of labor allocation to farming and nonfarming reveals that the farmgate terms of trade between farm and nonfarm products, the level of household capital (tools and seeds) input per working unit (adult-equivalent), and the state of infrastructure are the key factors explaining the share of household labor time allocated to either farm or nonfarm income-generating activities in the Zairian Basin. The elasticity estimate of the share of household labor time allocated to agriculture is about 0.27 with respect to farmgate terms of trade between farm and nonfarm products, 0.26 with respect to household capital input per working unit, and 0.23 with respect to the state of infrastructure. For other income-generating activities, the elasticity estimate of the share of household labor time allocated to this group of activities is about −0.22 with respect to farmgate terms of trade between farm and nonfarm products, 0.10 with respect to capital input per working unit, and 0.21 with respect to the state of infrastructure.

Labor time allocated to agriculture by both men and women in the Zairian Basin is primarily used in the production of cassava, rice, maize, and plantain. The amount of labor use per hectare of cultivated area in this tropical rain forest zone was estimated at 1,717.1 adult-equivalent hours in the 1982/83 crop year. This high labor use per hectare was found to be significantly affected by the timing of farm operations. The study estimated that a 1.00 percent increase in the number of households observing the timing of farm operations recommended by the extension service would be associated with a 0.51 percent decrease in the amount of labor use per hectare of cultivated area.

In addition, the analysis shows that male labor time allocated to land preparation and the timing of this farm operation are the main determinants of the size of cultivated area in the Zairian Basin. The study also found that a 1.00 percent increase in the number of households observing the correct timing of farm operations would lead to a 0.47 percent upward shift in the production function curve, while a 1.00 percent increase in the number of households using a rice-maize crop mix would be associated with a 0.42 percent downward shift in the agricultural production curve. Compared with cassava and plantain, rice and maize are biologically less productive in terms of energy per unit of land and time.

Furthermore, the average and marginal products of male labor are estimated at 6.9 and 3.0 kilograms of cereal-equivalents per hour of work, respectively, and those for female labor time are 5.1 and 1.7 kilograms of cereal-equivalents per hour of work. The overall average and marginal products of labor amount to 2.6 and 2.0 kilograms of cereal-equivalents per hour of work, respectively. These estimates of labor productivity vary by a factor of about 6 across households.

The analysis also indicates that the households that did not observe the correct timing of farm operations could have achieved about a 60.0 percent increase in their labor productivity if they had, and the entire sample would have increased its labor productivity by about 14.0 percent. The sample data indicate that 32.6 percent of the 132 study households did not observe the recommended agricultural calendar.

The study underscores the importance of the farmgate terms of trade, household capital input, and infrastructure in the process of labor allocation among farming, nonfarming, and other household activities carried out in the Zairian Basin. It also reveals that an appropriate timing of farm operations has a positive and significant effect on farm output and labor productivity. It concludes that, in the long run, development of capital (credit) markets and improvement and expansion of the road network and marketing channels need to be pursued. And for the short or medium term, the extension service should consider educating farmers to observe the recommended agricultural calendar. Therefore, efforts to improve research, extension, and weather forecasting need to be undertaken.

2

INTRODUCTION

Labor input accounts for more than 70 percent of agricultural output in most of the Sub-Saharan region. Therefore the need to increase the productivity of labor input allocated to agriculture is central from the standpoint of both growth and equity in this region (Eicher and Staatz 1984; Mellor, Delgado, and Blackie 1987; Delgado and Tshibaka 1990).

Despite the paramount importance of labor, the amount of time spent on farming by most African farmers over a year is generally low even during seasonal peak periods. In the Toro area of Uganda, an average household was found to spend one hour per person per day in farming (Pudsey 1967). In the Uboma area of Nigeria, Oluwasanmi et al. (1966) found that a male household member spent an average of 3.4 hours per day on farming, while his female counterpart devoted 2.4 hours per day to farm work during the cropping season. However, Massell and Johnson (1968) found in their study of smallholder farmers in Zimbabwe that farmers worked from 4.5 to 7.0 hours per day.

The allocation of labor to farming in Sub-Saharan Africa was also found to be affected by the traditional consideration of many farm operations as being age- and gender-specific. Thus the extent of specialization in labor use by gender has received particular attention. In Sierra Leone, Spencer (1976) reported that women spent 900 hours per year in farming, compared with 1,450 hours for men. In northwest Tanzania, Shapiro (1978) observed that women contributed more than 28 percent of the total hours worked. In northern Nigeria, where Moslem social customs prevail, farm work is carried out almost exclusively by men (Luning 1967; Matlon et al. 1979). In some areas, men concentrate on the production of cash crops, while women take sole responsibility for production of food. In general, the heavy tasks are carried out by men, with women weeding and harvesting the fields (Cleave 1974; Niang 1980). Several reports indicate that traditional divisions of labor are breaking down in many areas. Heyer (1966) noted that in Kenya the traditional labor organization is disappearing, and both men and women participate during plowing time and weeding season.

Cleave (1974) argued that although seasonality of agriculture partly explains the low labor use in farming in Africa, it is common for adult family members to work on the land only 20-40 hours a week during the peak periods. Norman, Pryor, and Gibbs (1979) found that more than 50 percent of the time allocated to farming in Hausaland in Northern Nigeria was concentrated in four months. However, Ruthenberg (1980) indicates that seasonal labor peaks are more acute in a permanent cultivation system than in a fallow system. Furthermore, in subhumid and semi-arid areas of Sub-Saharan Africa, the distribution of rainfall imposes a pattern of labor use and allocation to farming that results in seasonal labor shortages during peak periods. These shortages do not occur in humid areas of the Sub-Saharan region because the distribution of rainfall there allows for farming all year round (Tshibaka 1989).

It is clear from this survey of literature that previous labor studies conducted in Sub-Saharan Africa have tended to concentrate mostly on describing the division of labor, estimating the amount of labor allocated to agriculture and other household activities, examining the seasonality of labor time spent on agriculture, and estimating the productivity of labor input and the contribution of this input to farm output. It is critically important to note that these studies have overlooked two other significant aspects of labor allocation and use in Sub-Saharan agriculture. First, they failed to pay enough attention to the effects of economic variables on labor use and allocation. Second, they failed to examine the effect of timing of different farm operations on the amount of labor used and on the productivity of this input.

In his work on X-efficiency, Leibenstein (1966) explicitly recognizes that "the inputs may have a fixed specification but yield a variable performance depending on the exact nature of their employment." This implies that *when* and *how* resources are used in the production process affect the level of technical efficiency and consequently the level of resource productivity. Following Leibenstein, the timing of different farm operations and the way these operations are carried out have a significant impact not only on labor use but also on the productivity of this and other farm inputs. In a study conducted in Sarawak and Sabah states of Malaysia, where shifting cultivation is still prevalent, Cramb (1989) also concluded that timing is an important factor leading to higher returns to labor. Timing affects the effectiveness of burning, and good burning results in a reduced labor requirement (for clearing, planting, and weeding) and increased farm output per unit of labor and land.

Furthermore, the extent to which the timing of agricultural labor use reflects the recommended agricultural calendar is a strong indication of the effectiveness of the extension services. This variable also provides some indication of the managerial and technical skills of the farmers, which constitute an important indicator of the stock of human capital available in the area. The timing of agricultural labor use has serious implications for the productivity of labor and other agricultural inputs.

Finally, it is important to stress that the rural household economy in the Zairian Basin has received little research attention to date. In fact, to most development economists and other social scientists, the area as a whole is among the least-known areas of the developing world.

Objectives of the Study

This study attempts to document the labor issues discussed above in order to fill some gaps in the understanding of the rural household economy in the Zairian Basin. More precisely, it describes the division of household labor time between males and females, examines the structure and seasonality in labor allocation among different household activities, and identifies key factors that determine the allocation of this resource. In addition, the study conducts a detailed analysis of labor use in the small-farm sector of the rural household economy by examining the structure of labor allocation among different farm operations, estimating the intensity of labor use, and assessing its determinants.

Furthermore, the study establishes the relationship between labor input and cultivated area, estimates the contribution of male and female labor to cultivated area, and examines the effect of timing on the size of cultivated area. The study also derives the relationship between the amount of labor input, the timing of farm operations, and the level of farm output, and from this relationship it estimates the contribution of male and female labor to farm output, computes the productivity of male and female labor, and appraises the effect of timing on both farm output and labor productivity. Finally, some policy implications and conclusions are drawn.

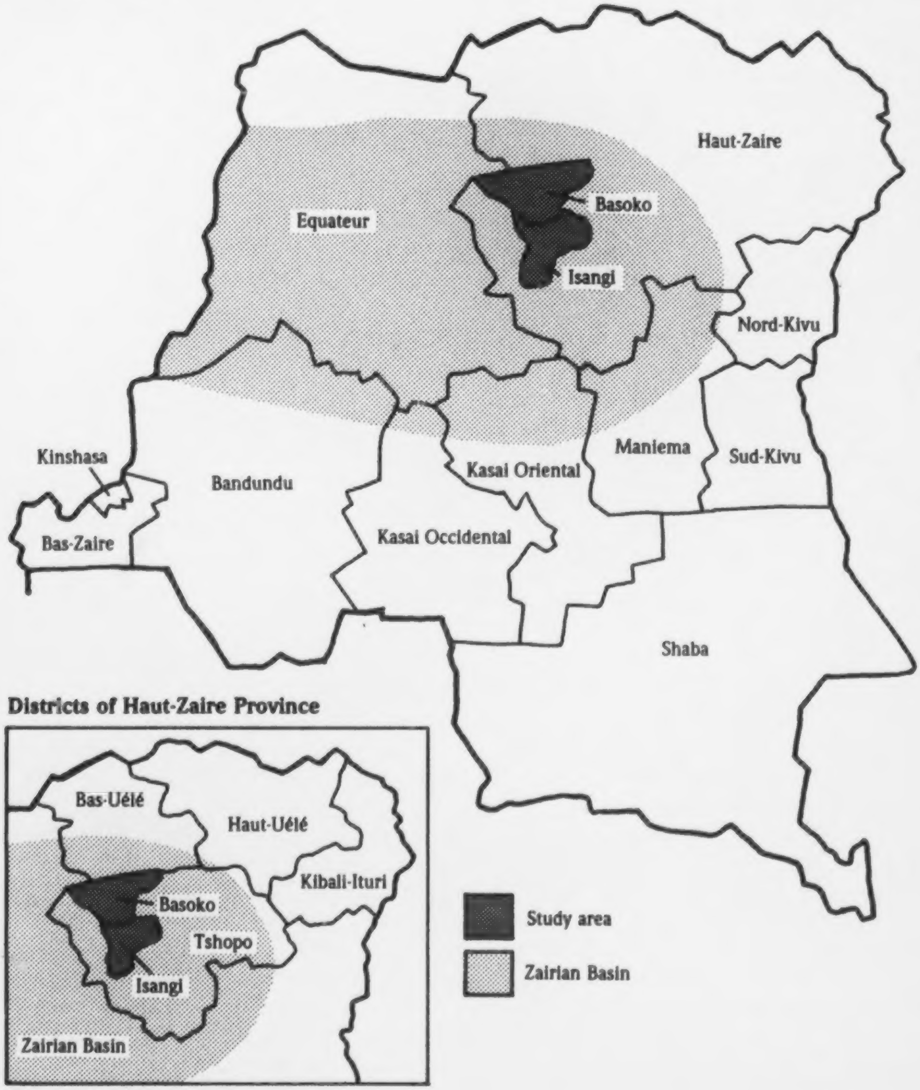
Data Sources and Limitations

The data used in this research report were derived from a household survey conducted during the 1982/83 crop year by the author in the rural communities of Turumbu, Mongandjo, and Bomaneh located in Isangi and Basoko zones, Tshopo District. This district is located in the rain forest part of Haut-Zaire Province (see Figure 1). To form the study area, six subareas were selected on the basis of the level of development of the road network system (Tshibaka 1989). A sample of 132 households was studied. These households were chosen following a proportionate, stratified sampling procedure. First, a number of villages were randomly drawn in each subarea. Second, taking account of the population of selected individual villages, a number of households were randomly drawn in each selected village.

One enumerator and an aid were posted in each subarea for one crop year. Two research assistants were allocated to the project to help supervise the survey. Selected households were visited by enumerators four times a week for one crop year, and two techniques of data collection were used: interview and direct measurement. Data were collected on population, infrastructure, input, output, and prices. Enumerators measured perimeters and angles of land under crops using tape measures, compasses, and pickets, and cultivated area was estimated by the triangulation method. The most serious difficulty during this survey was the assessment of time spent on different activities, which is affected by farmers' own judgment and that of the enumerators. With regard to capital, farmers do not easily recall the monetary value of their tools or the date of acquisition. These limitations are hard to avoid in a situation where most farmers are illiterate or do not keep records. A statistical method proposed by the Institut National des Statistiques et d'Etudes Economiques de France was adopted to estimate the cultivated area allocated to individual crops. The proposed method, notwithstanding its limitations, provides estimates that are useful when studying a mixed-crop farming system. (For details about the data see Tshibaka 1989.)

The allocation of time spent on nonspecific farm operations such as land preparation and weeding among individual crops was made on the basis of area shares of individual crops. For capital tools—mainly hoes, cutlasses, and hatchets—the labor time allocated to each of the four major crops (cassava, rice, maize, and plantain), expressed as a fraction of total labor time devoted to farming, was used as a weight to calculate the depreciation (in zaires) of capital tools used in the production of each crop. Since most of the tools used in the area are hand-held, their use is highly correlated with labor input per crop.

Figure 1—Map of Zaire


Haut-Zaire
Equateur
Basoko
Isangi
Nord-Kivu
Maniema
Sud-Kivu
Kasai Oriental
Kinshasa
Bandundu
Bas-Zaire
Kasai Occidental
Shaba
Districts of Haut-Zaire Province
Bas-Uélé
Haut-Uélé
Kibali-Ituri
Basoko
Tshopo
Isangi
Zairian Basin
Study area
Zairian Basin

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986.

3

THE STUDY AREA

Ecology

The study area, located in Tshopo District, Haut-Zaire Province, is made up of three communities: Turumbu people in the administrative zone of Isangi; Basoo people in Bomaneh, Bomenge Rural Community; and Bangelima people in Mongandjo Community in the administrative zone of Basoko. This area belongs to the Zairian Basin, which covers almost 40 percent of the total land area of Zaire. The tropical rain forest that covers the Zairian Basin is a very rich biocenosis with a large number of species of trees, birds, animals, insects, and microorganisms. Some of these organisms constitute a major environmental constraint to agricultural production in this area.

Rainfall exhibits a bimodal distribution pattern and averages 1,800 millimeters a year. There are two rainy seasons, one between March and May and the other between August and November, and two dry seasons, one between January and February and the other between June and July. The area receives an average of 1,972 hours of sunlight per year, representing 45 percent of the days of possible sunshine. Most of this sunshine is concentrated during the dry seasons of the year. Temperature and humidity average respectively 25.5°C and 90 percent a year (Crabbe 1970).

Soils are leached and have a pH varying between 4 and 6. High surface heat and hard, frequent rains lead to a rapid breakdown in organic soil materials. The organic matter content of these soils varies between 1 and 2 percent (Sanchez 1976). As a result, fertility is low. Once land is cleared and put under cultivation with annual crops, soils are rapidly depleted. This low soil fertility forces farmers, in the absence of inputs to improve soil fertility, to clear new plots of land every cropping season. This shifting cultivation mode of production is becoming increasingly unsustainable with rapid population growth and, above all, constitutes a wasteful use of forest resources.

Rural Household Economy

The rural household economy of the study area evolves around two major sectors: the small-farm and nonagricultural sectors. The small-farm sector relies mostly on household labor, which is the main determinant of production. The capital input is composed largely of hand tools and seeds from previous crops. Land is abundant and freely accessible to every household. In 1982/83 the area cultivated by each household ranged from 0.25 to 1.09 hectares. Traditional techniques of production are still in use, and technological change occurs so slowly in the small-farm sector that it is hardly noticeable. The slash-and-burn method continues to be the mode of production. The major crops produced in the small-farm sector are food crops including rice, maize, cassava, and plantain. Rice and maize are primarily produced as cash crops, while cassava and plantain are mostly grown for subsistence.

The nonagricultural sector includes several activities that can be classified as food-producing or non-food-producing. Living in a very rich biocenosis, households engage extensively in hunting, fishing, and gathering to produce the bulk of the protein-based foods consumed in the area. These activities are also an important source of cash income for most of the households in the area. Non-food-producing activities are handicrafts, petty trade, and production of alcoholic beverages.

The area also has a plantation sector owned mainly by large foreign-owned corporations. This sector depends on paid inputs—labor and capital—and produces entirely for markets. The bulk of its output includes coffee, cocoa, rubber, and palm oil. The plantation sector sells very little to the smallholder sector. The smallholder sector sells food and nonfood products as well as a limited amount of labor to the plantation sector. There has not been any competition for land between these plantations and the local communities, even during the period of rapid expansion of the plantation sector (Jurion and Henry 1967). Since the 1960s, this sector has been contracting because of a number of inappropriate policies and poor management of the economy (Tshibaka 1986).

Historically, the establishment of this plantation agriculture was achieved with labor supplied mainly by the rural households in the study area. Over the years, the plantations have succeeded in reproducing most of their own labor force. That is, the children of the people who migrated from a rural household economy into the plantation economy were and still are the primary source of labor used by the plantation sector. None of the study household members were found to be engaged in plantation agriculture during the survey. The linkages between the two sectors are primarily limited to the flow of food, other household products, and a limited labor force from the smallholder sector to this large-scale agriculture. In fact, the plantation and the smallholder sectors constitute two distinct socioeconomic entities.[1]

Basic Infrastructure

The Zairian Basin is the least developed region in the country, as is reflected in the poor state of the road network and consequently of the transportation system. Most villages in the region are isolated or poorly connected to major markets and urban centers. There are differences from one group of villages to another in the physical condition of the roads and in distances to rural markets or urban centers, making some villages more accessible than others. Most Turumbu villages are served by the Zaire River and the Isangi-Yangambi-Kisangani road. Local traders provide the sole means of transportation on the river, the traditional canoe. The traders are Lokele people, who play an important role in the distribution and marketing of farm and nonfarm commodities produced by Turumbu farmers. Although canoes are used all year round, the volume of goods transported remains small and the risk of accident high.

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[1] This is also the case for the mining sector in Zaire. The plantation and mining sectors are economic entities that have succeeded in creating their own identity. This anthropological aspect of the relationship between the rural household economy and the plantation agriculture is beyond the scope of this study.

The Isangi-Yangambi-Kisangani road, considered to be a major national road, is unpaved. Even during relatively dry periods of the year, the use of this road by vehicles is limited. Covering the 97 kilometers that separate Yangambi and Kisangani may take three hours in the best of weather conditions. During wet periods, the road is seldom used by vehicles. The high level of precipitation in the Zairian Basin makes the use of unpaved roads by vehicles difficult during most of the year. As a result, Turumbu villages along this axis are poorly connected to Yangambi and Lotokila—the major local markets in the community—and to Kisangani, the major urban center. Farmers living along this road usually walk 4-23 kilometers, depending on the location of their village, to reach a rural marketplace.

A second group of Turumbu villages, even more isolated, includes Weko and Yambaw in the remote forest. The road connecting these villages to Yangambi has deteriorated to such an extent that it is no longer used by vehicles at all. Farmers bring their produce twice a week to a local marketplace (which is 1 kilometer from Weko and 12 kilometers from Yambaw) for sale to traders, most of whom come from Yangambi by foot or bicycle. The distance from this local market to Yangambi is about 42 kilometers.

In the Mongandjo Community, farm households are served by the Aruwimi River and two feeder roads. The 42-kilometer road connecting Bolikango to Basoko is the best maintained in the entire study area. It was in fair condition for seven months of the survey year, in poor condition for three months, and in very poor condition for two months. Farmers walk 5-23 kilometers to reach three rural marketplaces: Longote, Bokote, and Baonde. The first two are along the Aruwimi River, while the third is at the point where the Basoko-Baonde route crosses the Aruwimi River. Farm and nonfarm products sold there are transported by traditional canoes or vehicles to Basoko, an important river port and marketplace.

The 190-kilometer road connecting Babendja in Mongandjo Community to Basoko is the second-best road in the area. This road was in fair condition for five months and in poor condition for the rest of the 1982/83 crop year. Babendja farmers walk 4-13 kilometers to reach a local market, where farm and nonfarm products are sold and then transported to Basoko either by road or by the Aruwimi River. The Aruwimi is used all year round by small boats and canoes. The distance by water from Babendja to Basoko is about 105 kilometers.

The 21-kilometer road connecting Bomaneh to Basoko in Bomenge Community is no longer practicable for vehicles, and it is now left entirely to those on foot. Only the Aruwimi River connects Bomaneh farmers to the two marketplaces—Baonde, 23 kilometers away, and Basoko, 24 kilometers. Canoes and small boats are the means of transportation used by farmers to reach these rural markets.

Data on the condition of the roads and the navigability of rivers in the area are summarized in Table 1. The table shows that Mongandjo and Bomaneh (Bomenge) farmers are in a somewhat better position than Turumbu farmers. The negative impact of this poor road network on the development of local marketing channels cannot be overemphasized. In all, the transportation system in the study area is grossly inadequate. For this and other reasons, few plantations are now operating in the study area.

Labor Force

The population of the study area was estimated at 49,103 people in 1981 (Zaire 1983). This population is growing at an annual rate of 1.2 percent, substantially lower

Table 1—Practicability of roads and navigability of rivers, 1982/83

Transport Route Destinations	Condition of Road or River			Distance from Primary (Local) to Secondary Markets	Community Served	Villages Served
	Fair	Poor	Very Poor			
		(months)		(kilometers)		
Yangambi-Kisangani (road)	0	5	7	97	Turumbu	Villages along the Yangambi-Kisangani road
Yangambi-Weko (road)	0	0	12	42	Turumbu	Villages in remote forest (Weko and Yambaw)
Yangambi-Isangi (road)	0	5	7	97	Turumbu	Villages along the Yangambi-Isangi road
Basoko-Baonde (road)	7	3	2	47	Mongandjo	Bolikango
Basoko-Mongandjo (Aruwimi River)	8	4	0	105	Mongandjo	Babendja
Basoko-Bomaneh (Aruwimi River)	8	4	0	24	Bomenge	Bomaneh

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

than the national average growth rate of 2.8 percent a year. The sample population data in Table 2 are drawn from 132 households, of which 53 are in Turumbu Community, 53 in Mongandjo, and 26 in Bomenge. The sample population consists of 885 people, of whom 48 percent are males and 52 percent are females.

Considering the age bracket of 20-55 years as the most productive group, the survey data reveal that this group of people accounts for 16.5 percent of the males and 22.7 percent of the females. The group in the age bracket of 15-19 years—those who will enter the set of the most productive people in the near future—includes 4.1 percent of the males and 3.4 percent of the females. The group of those more than 55 years of age accounts for 6.0 percent of the males and 5.3 percent of the females.[2]

A large proportion of the sample population—about 42 percent—is under 15 years of age. The youthful character of the study population is further portrayed by a relatively low median age of 19. Demographically, a large proportion of people under 15 means that much momentum for future growth in the labor force in the study area is already built into the population. Another interesting feature of the sample population is the relatively small fraction of people in the 20-49 age bracket. This seems to suggest a substantial age- and gender-specific migration out of the study area, in addition to a relatively high death rate.[3]

In a subsistence-oriented economy, young adults are engaged in economic, social, and cultural activities in varying degrees. The definition of economically active people or the work force, that is, the group in the 15-64 age bracket, needs to be modified to show that even children below 15 and adults of 65 and above contribute to the household labor force in the peasant economy. There is recognition among researchers that due to labor division along gender lines, adult men and women in the 20-55 age bracket are equally efficient in performing specific tasks—for example, land preparation for men and planting, weeding, and harvesting for women; collection of palm nuts for men and processing of these nuts for women (Spencer 1976; Dodge 1977). On this basis, one adult man or woman is equivalent to one working unit. The same researchers seem to accept that female children work harder than their male counterparts.

The structure of the labor force is shown in Table 2. The sample population of 885 people represents 491.2 working units made up of 44.3 percent males and 55.7 percent females. The most productive group (20-55 age bracket) accounts for 70.6 percent, made up of 29.7 percent males and 40.9 percent females. In all, the data show that the share of females in the household labor force is, on average, relatively larger than that of males. The average household labor force in the study area is about 3.7 working units, of which 1.6 are males and 2.1 females.[4]

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[2] In Zaire, farmers more than 55 years of age are considered retired farmers.

[3] Life expectancy in Zaire as a whole was about 45 years of age at the time of the survey. It is possible that this age may have dropped as a result of persistent socioeconomic crisis.

[4] The following conversion factors adopted from Collinson (1972) were used after adjustment for female children: 0.25 for males in the 10-14 age bracket, 0.67 for males in the 15-19 age bracket or more than 55 years of age, 0.37 for females in the 10-14 age bracket, and 0.75 for females in the 15-19 age bracket or more than 55 years of age.

Table 2—Sample population in the study area

Sex/Age	Number of People	Percent of Total Sample
Male		
0-4	74	8.36
5-9	69	7.80
10-14	48	5.42
15-19	36	4.07
20-24	26	2.94
25-29	31	3.50
30-34	19	2.15
35-39	15	1.69
40-44	11	1.24
45-49	19	2.15
50-55	25	2.82
More than 55 years old	53	5.99
Total males	426	48.14
Average males per household	3	. . .
Female		
0-4	75	8.47
5-9	66	7.46
10-14	40	4.52
15-19	30	3.39
20-24	43	4.86
25-29	28	3.16
30-34	26	2.94
35-39	29	3.28
40-44	22	2.49
45-49	26	2.94
50-55	27	3.04
More than 55 years old	47	5.31
Total females	459	51.86
Average females per household	3	. . .
Male and female		
0-4	149	16.83
5-9	135	15.26
10-14	88	9.94
15-19	66	7.46
20-24	69	7.80
25-29	59	6.67
30-34	45	5.08
35-39	44	4.97
40-44	33	3.73
45-49	45	5.08
50-55	52	5.88
More than 55 years old	100	11.30
Total males and females	885	100.00
Average per household	6	. . .

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

4

DIVISION AND ALLOCATION OF HOUSEHOLD LABOR TIME

Description of Household Activities

All the activities carried out in rural households in the Zairian Basin can be conveniently grouped into two broad categories: income-generating and non-income-generating. Income-generating activities include farm and nonfarm activities. Farming in the area is undertaken in the slash-and-burn fallow mode of production in which simple hand tools, on-farm crop seeds, household labor time, and land are the productive inputs. Land is abundant and freely accessible to all the households. The four major food crops are cassava, rice, maize, and plantain—all energy-rich foods (Tshibaka 1989).

Nonfarm activities can be divided into food-producing, non-food-producing, and service activities. Nonfarm food-producing activities consist of hunting; fishing; gathering edible wild fruits, leaves, mushrooms, insects, and honey in the forest; and the extraction of oil from wild palm nuts. These activities provide most of the protein-, mineral-, and vitamin-rich foods consumed in the Zairian Basin. Nonfood commodities and services include handicrafts, processing of maize into alcohol, extraction of wine from wild palm trees, and petty trade.

Non-income-generating activities include a wide variety that can be grouped into domestic and other activities. Domestic activities include building and maintaining houses; cooking; dishwashing; fetching water and firewood; health care; taking care of children; washing, mending, and ironing clothes; and so on. Other non-income-generating activities include sociocultural activities and leisure. Sickness and disease are also included in this group. Sociocultural activities are made up of schooling; attending political meetings, church services, parties, traditional dances, and festivals; and visiting friends and relatives. These activities are often viewed as noneconomic, as they generally carry no monetary remuneration. It should be emphasized, however, that they are essential functions that ensure the reproduction and maintenance of human resources for the household and the nation.

Division of Household Activities

In most societies, the division of different activities performed in the household follow, to varying degrees, age and gender lines. The survey shows that high-energy and risky tasks are mainly reserved for adult male members of the household, while lighter and less risky tasks are primarily handled by adult women. The same pattern of labor division applies to children. Male children are coached by men, while female children are trained by women.

In relation to farming activities, the survey data indicate that slashing of forest or fallow and burning are mainly carried out by males, while clearing, planting, weeding, harvesting, processing, transporting, and marketing are primarily responsibilities of females. As for nonfarm activities, hunting, fishing, gathering wild palm nuts, extracting palm wine, and making handicrafts are mainly done by males, while collecting food items such as mushrooms, insects, and wild edible leaves, extracting oil from wild palm nuts, processing maize into alcohol, and marketing are primarily performed by females. Petty trade is handled by both males and females.

Most domestic activities are the responsibility of females, except for gardening, building and maintaining houses, and sociocultural activities, which are performed by both males and females. Nevertheless, it should be pointed out that some sociocultural activities such as traditional festivals and secret initiations are reserved either to males or females. The whole picture of labor division along gender lines in the study area is summarized in Table 3.

Labor Time Allocation among Household Activities

Labor data were collected only during daylight hours, and the observations covered the 365 days of the 1982/83 crop year. Labor time allocated during the 12 hours of daylight to each activity by individual household members aged at least 10 years was aggregated for each household using some conversion factors to account for age and gender differences (Collinson 1972; Spencer 1972; Dodge 1977).

It is important to note that this study, like most time-allocation studies confined to daylight hours, is likely to contain selective biases. Activities requiring daylight to accomplish (such as farming and house construction) are overrepresented, while those that can be practiced at night (such as visiting and rituals) are underrepresented.[5] However, the bulk of income-generating and non-income-generating activities are carried out in the Zairian Basin during daylight hours. The structure of daylight time allocation between these two groups of activities is shown in Table 4.

The data show that household members allocated, on average, 21.8 percent of their annual labor time to income-generating activities, of which 6.1 percent was spent on farming and 15.7 percent on nonfarm activities. This finding clearly indicates that, in the Zairian Basin, nonfarm income-generating activities—hunting, fishing, gathering, handicrafts, and production of alcoholic drinks—are the leading economic activities. Although vital as a major source of food for the household, farming remains of secondary importance as an economic activity in the study area. A survey conducted in 1974/75 on a small sample of households in Yalibwa, Turumbu Community (Kilumba 1975), revealed that the contribution of nonfarm activities to household cash income (after taking account of home consumption) was larger than that of farming. The surplus from these activities contributed about 62 percent

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[5] Nighttime is assumed to be a period of time after 7:00 p.m. and before 6:00 a.m. Daytime (daylight) is assumed to be a period of time after 6:00 a.m. and before 7:00 p.m. The Zairian Basin extends north and south of the equator.

Table 3—Division of household activities by gender in the study area

Activities	Males	Period of the Year	Females	Period of the Year	Males and Females	Period of the Year
Income-generating						
Farming	Land preparation (slashing, burning)	January through April	Planting, sowing, weeding, harvesting, processing, transporting, and marketing	January through December	Land clearing	March through April
Nonfarming	Hunting, fishing, gathering nuts from wild palm trees, extracting and marketing wine from wild palm trees, and handicrafts	January through December	Gathering different food products in the forest, extracting oil from wild palm nuts and marketing oil, processing maize into beer and alcohol and marketing them, and crafts	January through December	Petty trade	January through December
Non-income-generating						
Domestic	. . .	. . .	Housework (cooking, dishwashing, fetching water and firewood, taking care of children, washing, mending, and ironing clothes)	January through December	Gardening, building and maintaining houses, health care	January through December
Other	. . .	. . .	. . .	. . .	Schooling, meetings, church services, leisure, and so forth	January through December

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Table 4—Allocation of labor among household activities, 1982/83

Activities	Males		Females		Males and Females	
	Hours per Working Unit[a]	Percent of Hours	Hours per Working Unit[a]	Percent of Hours	Hours per Working Unit[a]	Percent of Hours
Income-generating	1,063.85	24.29	868.75	19.83	955.22	21.81
Farming	258.53	5.90	272.26	6.21	266.18	6.08
Nonfarming	805.32	18.39	596.49	13.62	689.05	15.73
Non-income-generating	3,316.15	75.71	3,511.25	80.17	3,424.78	78.19
Domestic	682.01	15.57	1,133.46	25.88	933.37	21.31
Other[b]	2,634.14	60.14	2,377.79	54.29	2,491.41	56.88
Total annual potential time	4,380.00	100.00	4,380.00	100.00	4,380.00	100.00

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: The potential time per working unit is estimated at 4,380 hours a year on the basis of 12 hours of daytime and 365 days a year. Daytime (daylight) is assumed to be a period of time after 6:00 a.m. and before 7:00 p.m.

[a] A working unit is defined as an adult-equivalent.

[b] Other includes non-income-generating activities such as sociocultural activities and leisure.

of household cash income as opposed to 36 percent from farm products. The remaining 2 percent of household cash income was provided by gifts and other donations.

The observation of the same data along gender lines reveals that male household members spent more time on income-generating activities than their female counterparts (Table 4). Males devoted 24.3 percent of their working time to these activities, compared with 19.8 percent for females. Non-income-generating activities claimed 78.2 percent of total labor time, of which 21.3 percent was devoted to domestic activities and 56.9 percent to other non-income-generating activities. Males allocated about 75.7 percent of their working time to this group of activities, of which 15.6 percent was spent on domestic activities and 60.1 percent on other non-income-generating activities. Females spent about 80.2 percent of their working time on the same activities, of which 25.9 percent was allocated to domestic activities and 54.3 percent to other non-income-generating activities.

Looking at the contribution of each member to the household work load during the study year, the analysis indicates that an average male member of the household contributed about 22.5 percent more labor than his female counterpart to income-generating activities. The disaggregation of these activities into farming and nonfarming indicates that an average female devoted 5.3 percent more time to farming and 35.0 percent less time to nonfarm income-generating activities than her male counterpart. With regard to non-income-generating activities, an average female devoted 5.9 percent more labor than an average male to this group of activities. The disaggregation of these activities into domestic and other activities, reveals that an average female spent about 66.2 percent more labor time than her male counterpart on domestic activities, while an average male allocated 10.8 percent more time than his female counterpart to other non-income-generating activities during the study year.

This survey confirms the findings of previous studies conducted in Sub-Saharan Africa that men spend relatively more time on income-generating activities and less time on non-income-generating work than women. The study also reveals that on average in the Zairian Basin, women do not spend significantly more time on farming than men. This finding is supported by many other labor studies conducted in the Sub-Saharan region (Oluwasanmi et al. 1966; Luning 1967; Spencer 1976; and Matlon et al. 1979).

In sum, this analysis finds that both male and female members of the household allocate relatively less labor time to income-generating (farming and nonfarming) activities than to non-income-generating activities, and that farming receives only a relatively small fraction of household labor time allocated to income-generating activities. Therefore, an assessment of the key determinants of labor time allocation between income-generating and non-income-generating activities is called for to help in policymaking. That analysis is taken up in Chapter 5.

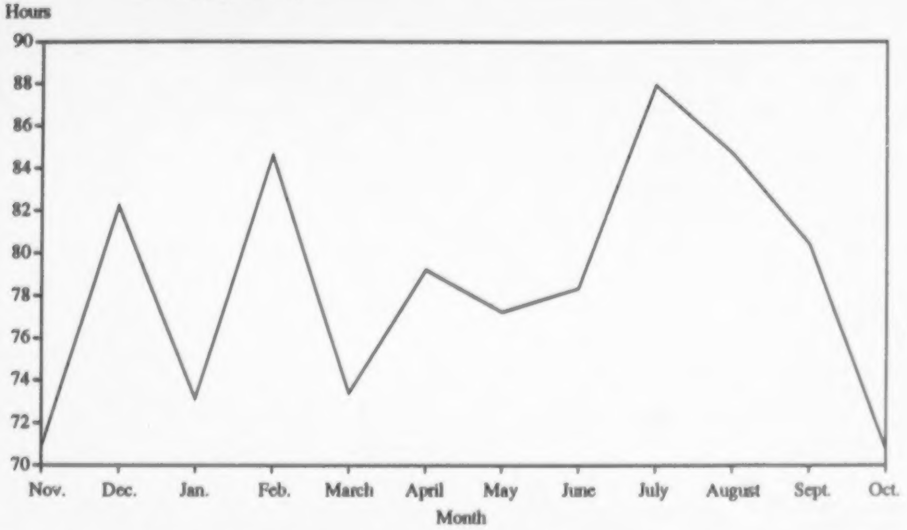
Seasonality in Labor Time Allocation

In a subsistence-oriented economy, rural household activities generally exhibit a certain degree of seasonality that reflects changes in the rainfall distribution pattern and other environmental conditions. These changes determine farming, hunting, fishing, and gathering periods, and consequently impose on the rural households a seasonal pattern of labor time allocation to both income-generating and non-income-generating activities. It is therefore important to examine this seasonality of labor use and allocation in order to pinpoint when labor shortages occur and whether these shortages occur during peak periods. This is particularly critical for farm operations such as land preparation, planting, weeding, and harvesting. In addition, it is useful to explore whether this seasonality in time allocation differs by gender in order to establish whether some policy recommendations related to labor use and allocation need to be gender specific.

The monthly allocation of male labor to income-generating and non-income-generating activities shows a seasonal trend (Figures 2 and 3). From November to April, male labor time allocated to income-generating activities does not show any discernible trend. From April to July, male labor time devoted to these activities exhibits an increasing trend, while from July to October, it shows a declining trend. With respect to the amount of male labor time spent on non-income-generating activities, three periods are identified: from November to April, an increasing trend; from April to August, a decreasing trend, and from August to October, an increasing trend. The trend in the monthly allocation of female labor time to income-generating activities declines from November to April, increases from April to August, and decreases from August to November (Figure 4). The situation is reversed for non-income-generating activities (Figure 5).

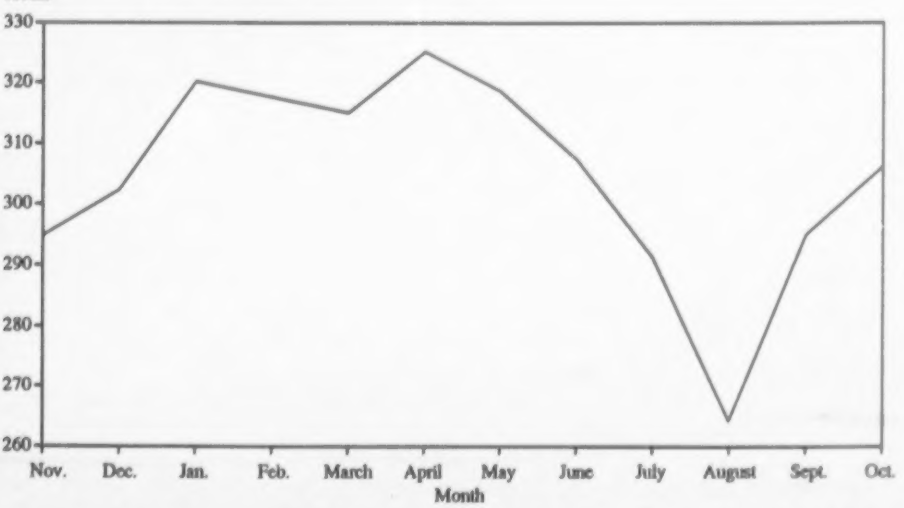
A further disaggregation of income-generating activities into farming and nonfarming reveals a seasonal pattern in the allocation of labor time to these activities. The allocation of male labor time to farming shows an increasing trend from December to February and a decreasing trend from February to December (Figure 6). The slashing of forest or fallow is mostly carried out during the December-February period. During February-April, burning and clearing are undertaken by most rural households. From April to December, other farm operations such as planting, weed-

Figure 2—Monthly allocation of male labor time to income-generating activities, 1982/83



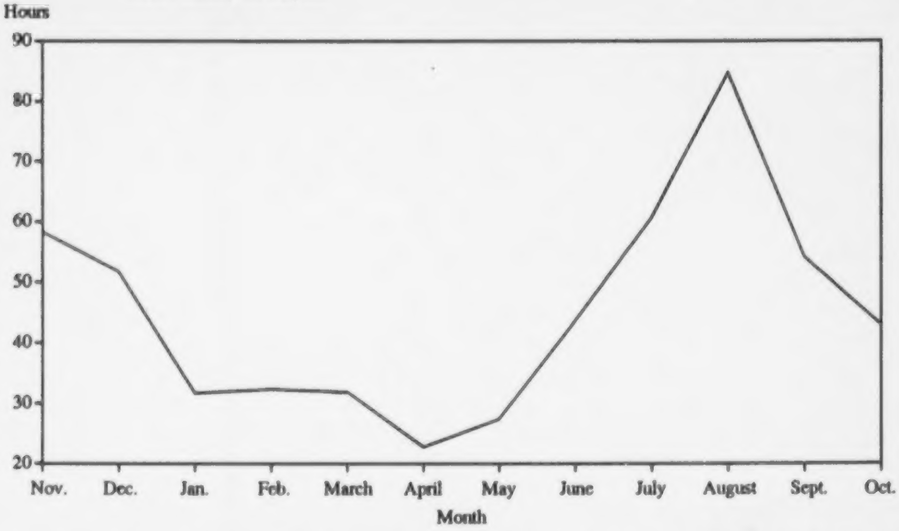
Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Figure 3—Monthly allocation of male labor time to non-income-generating activities, 1982/83



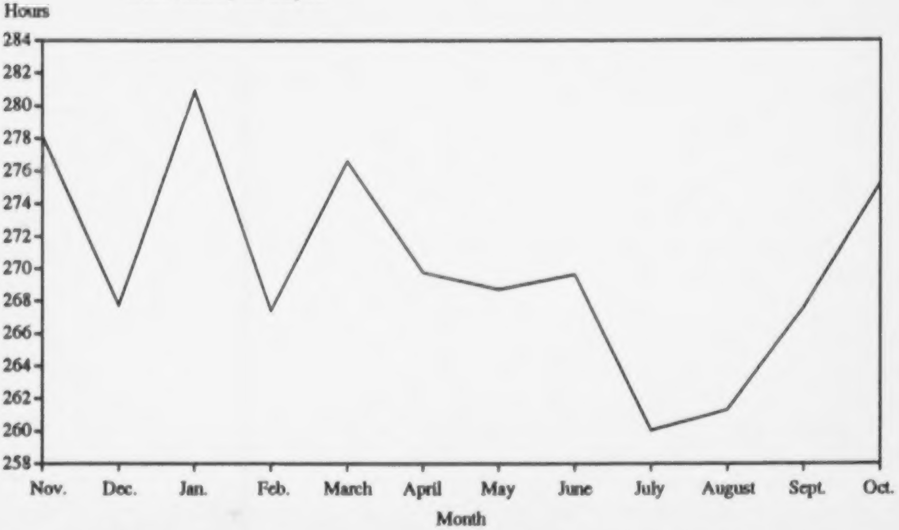
Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Figure 4—Monthly allocation of female labor time to income-generating activities, 1982/83



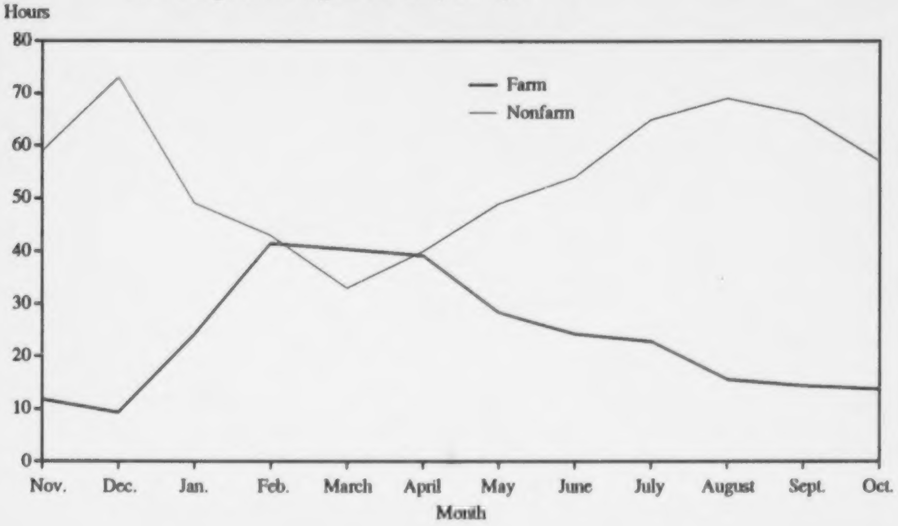
Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Figure 5—Monthly allocation of female labor time to non-income-generating activities, 1982/83



Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Figure 6—Monthly allocation of male labor time to farm and nonfarm income-generating activities, 1982/83



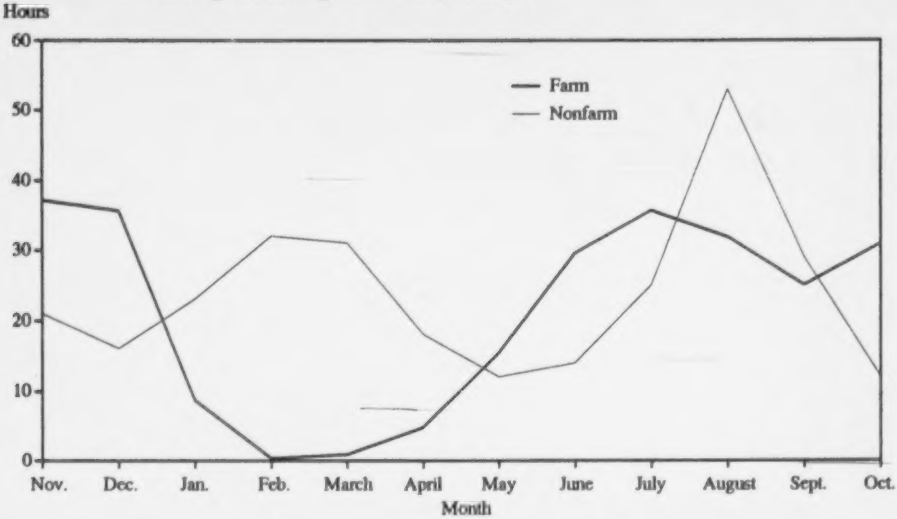
Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

ing, harvesting, processing, and marketing are performed. Male labor time spent on nonfarm activities displays a declining trend in December-March, increasing in March-August, declining in August-October, and increasing in October-December.

The monthly allocation of female labor time to farming shows a decreasing trend in November-February, increasing in February-July, declining in July-September, and increasing in September-November (Figure 7). From November to February, most females are engaged in processing and marketing farm produce. From February to July, they are generally clearing, planting, and weeding. From September to November they are harvesting (cassava and plantain), processing, and marketing. The monthly female labor allocation to nonfarm activities exhibits an increasing trend in December-February, declining in February-May, increasing in May-August, and decreasing in August-December.

This analysis shows that the allocation of labor time has different seasonal patterns for men and women. The time allocated to income-generating activities by an average male is greater than that of his female counterpart throughout the year except for August, when their monthly allocation of labor time to these activities is practically the same. The reverse holds for non-income-generating activities. In addition, the pattern of labor time allocation over the years reveals that forest or fallow slashing and burning are almost entirely carried out by men, while clearing, planting, weeding, harvesting, processing, and marketing are mainly performed by women, with substantial help from men.

Figure 7—Monthly allocation of female labor time to farm and nonfarm income-generating activities, 1982/83



Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Furthermore, the survey reveals that no male or female household member spent more than 50 percent of his or her available monthly labor time on income-generating activities during the entire 1982/83 year. Thus the observed pattern of labor use and allocation does not suggest any seasonal labor shortages in the study area. Moreover, given a bimodal distribution pattern of rainfall that allows for two cropping seasons a year, it is plausible to suggest that the limited labor allocated to farming during the survey year can hardly be attributed to seasonal variations in rainfall distribution—a major factor constraining labor use, particularly in the subhumid and semi-arid areas of Sub-Saharan Africa (Tshibaka 1989)—but rather to other factors this study attempts to identify in subsequent chapters.

5

DETERMINANTS OF HOUSEHOLD LABOR TIME ALLOCATION

Estimations of the amount of household labor time (expressed in adult-equivalent hours) allocated to different groups of household activities were given in Chapter 4. Next, the study attempts to identify key factors that determine the allocation of this labor time among these groups of activities, that is, the factors that determine how this labor input is shared among agricultural, nonagricultural, and other household (non-income-generating) activities. This assessment provides information on how to change the observed pattern of household labor allocation to enhance a specific group of activities—for example, income-generating activities including farming.

The Singh-Squire-Strauss Model

This section is an exposition of the existing SSS model (Singh, Squire, and Strauss 1986). The SSS model is used in an attempt to examine the key determinants of labor allocation among different household activities. Given the division of labor along gender lines and the high degree of interdependency between household members of both genders in this subsistence-oriented society, it is plausible to assume that the decisionmaking unit is the household and not the individual. For example, the amount of labor time female members allocate to farming is partly determined by the size of the cultivated area, which is primarily determined by the amount of labor males devote to land preparation. Since subsequent farm operations (planting, weeding, harvesting, transporting, processing, and marketing) are primarily performed by females, one may assume that during land preparation (slashing and burning), men will take into account the available household female labor force.

With regard to nonfarm activities—for example, production of oil from wild palm tree nuts—the amount of labor that males allocate to gathering palm nuts will be affected by the availability of the female labor needed in the processing and marketing of palm oil. This strong interdependency is exacerbated by the lack of a labor market in the area. Thus the household, rather than the individual member, should be considered as the decisionmaking unit.

It should be stressed that the model attempts to identify key demographic, environmental, economic, and sociocultural factors that enter the household's decisionmaking process related to allocation of the available labor time among different groups of activities including income-generating (farming and nonfarming) and non-income-generating (domestic and other) activities carried out in the rural household.

Before the model is postulated, it is important to note the following assumptions:

- The rural household in the Zairian Basin is assumed to be a utility-maximizing unit that tries to approximate the profit-maximizing solution.
- The production is competitive and subject to a homogeneous production function of degree one, exhibiting constant returns to scale.
- The resources available to the household are limited and fully employed. These inputs are labor and capital. Since land is abundant and freely available to each household, it is not a binding constraint to production.
- The production of farm products requires land, labor, and capital, and that of nonfarm products requires primarily labor and capital, while non-income-generating activities demand mainly labor.
- Labor is mobile between farming, nonfarming, and non-income-generating activities. Land is specific to agriculture, and capital is mobile between farming and nonfarming.

For any production cycle, the household is assumed to maximize a utility function:

$$U = U\,(V_a, V_n, V_m, V_o), \qquad (1)$$

where

V_a = set of household's own agricultural goods consumed,
V_n = set of household's own nonagricultural products consumed,
V_m = set of market goods purchased by the household, and
V_o = set of non-income-generating activities.

The household utility function is maximized, subject to a cash-income constraint:

$$P_mV_m = P_a(Qa - V_a) + P_n(Q_n - V_n) - w(L_a - H_a) - w(L_n - H_n) - r(K_a + K_n), \qquad (2)$$

where

P_m = set of prices of purchased goods,
P_a = set of prices of farm products produced in the household,
P_n = set of prices of nonfarm products produced in the household,
Q_a = set of household's farm outputs (so that $Q_a - V_a$ is the set of its marketed farm surplus),
Q_n = set of household's nonfarm outputs (so that $Q_n - V_n$ is the set of its marketed nonfarm surplus),
w = market wage,
L_a = total labor input allocated to agriculture,
H_a = household labor input allocated to agriculture,
L_n = total labor input allocated to nonagriculture,
H_n = household labor input allocated to nonagriculture,
r = cost per unit of household capital input,
K_a = household capital input allocated to agriculture, and
K_n = household capital input allocated to nonagriculture.

Note that $K_a + K_n = K$, which is the stock of household capital available during the production cycle. Note also that if labor was hired, then $L_a > H_a$ and $L_n > H_n$: hence

$L_a - H_a > 0$ and $L_n - H_n > 0$. If, on the contrary, some household labor is sold out, then the reverse holds. The household also faces a time constraint, so that

$$H_a + H_n + H_o = T, \tag{3}$$

where H_o is the household labor allocated to non-income-generating activities, and T is the stock of household labor time.

The transformation of the household's resources into farm and nonfarm products is constrained by the production technology that depicts the relationship between the set of the household's inputs and the set of its outputs. The aggregate farm and nonfarm production functions could be given as functions of labor and capital inputs:

$$Q_a = f(L_a, K_a), \text{ and} \tag{4}$$

$$Q_n = f(L_n, K_n). \tag{5}$$

This formulation is made on the basis that the volume of farm and nonfarm output in a land-surplus, labor-scarce economy is primarily determined by the amount of labor and secondarily by capital input allocated to farming and nonfarming (Tshibaka 1989). Since land is plentiful and freely available in the Zairian Basin, it is not a binding constraint to farm production and is therefore omitted from the aggregate agricultural production function.

Furthermore, the production of both farm and nonfarm goods is assumed to be riskless, and the household is assumed to be a price-taker. The three basic constraints of the model—cash, labor, and production—can be combined into a single constraint. Substituting the production constraint into the cash-income constraint for Q_a and Q_n and substituting the time constraint into the cash-income constraint for H_a and H_n yields a single constraint of the form

$$P_m V_m + P_a V_a + P_n V_n + wH_o = wT + \pi, \tag{6}$$

where $\pi = P_a f(L_a, K_a) + P_n f(L_n, K_n) - w(L_a + L_n) - r(K_a + K_n)$. In equation (6), the left-hand side shows total household expenditure on four groups of items—market-purchased goods, the household's purchase of its own farm output, the household's purchase of its own nonfarm output, and the household's purchase of its own time in non-income-generating activities (sociocultural and leisure). The right-hand side is a development of Becker's concept of full income, in which the value of the stock of household labor time is explicitly recorded. The extension for rural households includes a measure of household profits, $\pi = (P_a Q_a + P_n Q_n) - w(L_a + L_n) - r(K_a + K_n)$, with all labor valued at the market price, this being a consequence of the assumption of price-taking behavior in the labor market.

It follows from equation (6) that the household can choose the levels of consumption for the four groups of commodities and the amount of total labor for agricultural and nonagricultural production. Now consider the first-order conditions for maximizing agricultural and nonagricultural output with respect to labor:

$$P_a \, \delta Q_a / \delta L_a = w, \text{ and} \tag{7}$$

$$P_n \, \delta Q_n / \delta L_n = w. \tag{8}$$

That is, the household will equate the value of the marginal product of labor in farm production and that of labor in nonfarming with the market wage rate. It is important to see that each of these equations contains only one endogenous variable, L. The other endogenous variables—V_a, V_n, V_m, and H_o—do not appear and therefore do not influence the household's choice of the amount of labor time to be allocated to agricultural and nonagricultural activities.

Accordingly, equations can be solved for L as a function of prices (P_a, P_n, w) and the stock of capital input. Let the solution for L be

$$L_a = f(w, P_a, P_n, K_a), \text{ and} \tag{9}$$

$$L_n = f(w, P_a, P_n, K_n). \tag{10}$$

Since it was observed during the survey that the household had a fixed stock of labor time and that no labor was hired or sold out, labor allocated to farming and nonfarming (s_a, s_n) can be expressed as shares of the stock of household labor time. Equations (9) and (10) become

$$s_a = f(P_a, P_n, w, K_a), \text{ and} \tag{11}$$

$$s_n = f(P_a, P_n, w, K_n), \tag{12}$$

so that $s_a + s_n + s_o = 1$, where s_o is the share of non-income-generating activities in the stock of household labor time. It follows that the labor-allocation-share constraint makes the labor equation for non-income-generating activities redundant and it need not be estimated.

Regression Equations

The above theoretical model was based on the assumption that the production is competitive. This assumption implies, among other things, that the economic environment is the same for all households in the study area. The survey conducted in the six locations that form the study area does not support this assumption. These locations were not found to display the same level of infrastructural development (road network, transportation system, distribution system, and markets). This observation calls for the inclusion of the infrastructure in the analysis.

As shown above, the prices of farm and nonfarm products produced in the household and the household capital input affect the allocation of labor between farming and nonfarming. The prices of farm and nonfarm products are, in turn, affected by the level of infrastructural development facing each location. Therefore, the prices will be highly correlated with the infrastructure variable. But the terms of trade between agricultural and nonagricultural products will be neutral with respect to this variable. Thus the infrastructure and the terms of trade are expected to independently affect the level of labor input allocated to farm and nonfarm activities. In fact, in the process of labor allocation between farming and nonfarming, farmers tend to think in terms of relative prices between farm and nonfarm products. Therefore, the terms of trade between farm and nonfarm activities is the most appropriate price variable to include in the analysis. Because the capital input available to the household is mostly made up of simple tools such as cutlasses, hatchets, and knives that are used for both farm and nonfarm activities, the study found it more appropriate to consider the amount of household capital available to all the income-generating activities per working unit as a good proxy of the capital input allocated to either type of income-generating activity. This variable is expected to positively affect the amount of labor time allocated to agriculture and nonagriculture.

Since the study households are primarily subsistence-oriented, and given that only household labor is used, two demographic variables to introduce in the analysis in order to account for these two household characteristics are the dependency ratio and the gender composition of the household labor force. The dependency ratio variable is expected to affect positively the amount of labor allocated to farming—the primary source of food for the household. But this demographic variable is expected to affect negatively the amount of labor allocated to nonfarming. Output from nonfarm activities such as fishing, hunting, and gathering is not predictable. Therefore, as the number of dependents is high, farmers will tend to put a low premium on these activities. Regarding the gender composition of the labor force, it was observed that males tend to spend more labor time on nonfarm activities than females, while females tend to allocate more labor time to farming than males. Hence, the gender composition of the labor force, expressed as the share of women in the household labor force, is expected to affect positively the amount of labor time spent on farming, and negatively the amount of labor time devoted to nonfarming.

Furthermore, a key variable that is not introduced in this empirical model is the market wage rate. It should be recalled that during the survey, labor was not hired or sold out. This suggests that the labor market in the study area was almost nonexistent. Therefore the market wage rate is considered to be zero. Under this situation, the household demand for labor is equal to the supply of its own labor (Singh, Squire, and Strauss 1986).

Thus the regression equations to be estimated include the infrastructure, the terms of trade between farming and nonfarming, the household capital input per working unit, the dependency ratio, and the gender composition of the labor force. These equations can be expressed as

$$s_a = f(I, T_{an}, K/W, D_r, C_g, e), \text{ and} \tag{13}$$

$$s_n = f(I, T_{an}, K/W, D_r, C_g, e), \tag{14}$$

where

s_a = share of labor allocated to farming,
s_n = share of labor allocated to nonfarming,
I = infrastructure variable,
T_{an} = terms of trade between farming and nonfarming,
K/W = household capital per working unit,
D_r = household dependency ratio,
C_g = gender composition of the household labor force, and
e = error term.

It is worth noting that a similar empirical model was used by Bardhan (1984) in his analysis of the peasant labor supply in India. It is also important to note that this model attempts to examine cross-section variations in the labor supply by focusing on factors specific to the household units as well as on factors that describe the economic environment within which these households operate.

Definition of Variables

As specified above, the empirical model includes the following variables: household dependency ratio, gender composition of the household labor force, capital input per working unit, infrastructure, and terms of trade between farming and nonfarming. The dependency ratio is defined as the ratio of the number of household consuming units over the number of household working units. This variable indicates the number of people (expressed in adult-equivalents) one working unit must support.[6]

The gender composition of the household labor force is defined as the ratio of the number of working units ascribed to females over the total number of working units in the household. Due to a lack of data on household capital (tools and seeds) input available for productive purposes, the capital input allocated to farming was used as a proxy. This capital input is expressed in zaires per working unit. This variable was introduced in the model to account for the effect of productive household assets on labor use.

The practicability of roads, navigability of rivers, and size of the markets in the study locations are used as a proxy to express the state of infrastructure in the study area. On the basis of these data the six study locations were divided into two groups. A dummy displaying a value of one was used for any location with a relatively adequate state of infrastructure and a value of zero for any other location.

The preplanting weighted farmgate prices for maize, cassava, rice, and plantain were computed to represent the price of farm products. The share of each crop in the cultivated area was used as a weight, while the preplanting producer price of palm wine was used as a proxy for the price of nonfarm products produced in the household. These average prices were computed from monthly farmgate price data collected from September 1982 to March 1983. These prices were used to estimate the terms of trade between farm and nonfarm activities. Finally, Table 5 presents some statistics describing the dependent variables (shares of labor time allocated to agriculture and nonagriculture, respectively) and the explanatory variables specified above.

Regression Results

A least squares method applied to the survey data gives the regression results summarized in Table 6. For the share of household labor time allocated to farming, the regression equation shows that the fit is fair and the F-statistics are highly significant at the 1 percent level. As expected, the coefficients for the preplanting

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[6] The conversion factors proposed by Collinson (1972) were used to compute the number of consuming units for each household. One working unit equals one adult-equivalent.

Table 5—Statistical description of variables for labor time allocated to agriculture and nonagriculture

Variable	Mean	Standard Deviation	Coefficient of Variation	Definition
s_a	0.07	0.04	57.14	Share of household labor allocated to farming
s_n	0.17	0.10	58.82	Share of household labor allocated to nonfarming
T_{an}	1.88	0.84	44.68	Farmgate terms of trade between farming and nonfarming
K/W	32.06	24.45	76.26	Household capital input (in zaires per working unit)
D_r	1.59	0.38	25.15	Household dependency ratio
C_g	0.55	0.13	23.64	Gender composition of household labor force

Source: Based on data from T. B. Tshibaka "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

farmgate terms of trade between farming and nonfarming activities (T_{an}), the amount of capital input per working unit (K/W), and the state of infrastructure (I) are positive and significantly different from zero at the 1 percent level. This implies that these variables are key determinants of the share of household labor time devoted to farming in the Zairian Basin. The degree of dependency (D_r)—introduced in the equation on the assumption that large household size would generate pressure to allocate more labor time to farming in order to produce more food crops—and the gender composition of the labor force (expressed as the share of women in the household labor force) do not explain the share of household labor time spent on farming.

With respect to the share of household time allocated to other income-generating activities, the analysis indicates that the fit is fair and the F-statistic is highly significant at the 1 percent level. All the variables display the expected signs. These variables are statistically different from zero. This suggests that these factors explain the share of labor time spent on nonfarm income-generating activities.

The elasticity estimate of the share of household labor allocated to agriculture with respect to the preplanting farmgate terms of trade is 0.27, that with respect to capital input per working unit is 0.26, and that with respect to the state of infrastructure is 0.23. These results can be interpreted as follows with regard to the share of household labor time allocated to agriculture: a 1.00 percent increase in preplanting farmgate terms of trade between agricultural and nonagricultural activities will be associated with an increase of about 0.27 percent; a 1.00 percent increase in capital input per working unit will lead to about a 0.26 percent increase; and a 1.00 percent improvement in the state of infrastructure will be associated with about a 0.23 percent increase.

Table 6—Determinants of shares of household labor time allocated to farm and nonfarm activities

Explanatory Variables and Important Statistics	Shares of Household Labor Time Allocation	
	Farming (s_a)	Nonfarming (s_n)
Intercept	1.23 (0.76)	21.55 (4.55)***
T_{an}	1.02 (3.27)***	-1.74 (-1.91)**
K/W	0.06 (5.09)***	0.05 (1.47)*
I	3.55 (6.06)***	8.67 (5.07)***
C_g	-1.10 (-0.61)	-7.78 (-1.50)*
D_r	0.65 (1.01)	-1.52 (-0.81)
$\bar{R}^2$	0.43	0.33
F	20.79	14.13
n	132	132

Source: Based on data from T. B. Tshibaka "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: The numbers in parentheses are t-values. T_{an} is the farmgate terms of trade between farm and nonfarm activities, K/W is capital input per working unit, I is the state of infrastructure, C_g is the gender composition of the household labor force, and D_r is the degree of dependency.

*Significant at the 0.10 level.
**Significant at the 0.05 level.
***Significant at the 0.01 level.

The elasticity estimate of the share of household labor time spent on other income-generating activities with respect to the preplanting farmgate terms of trade between agriculture and nonagriculture is -0.22, that with respect to capital input is 0.10, and that with respect to the state of infrastructure is 0.21. This suggests that a 1.00 percent increase in the farmgate terms of trade between agriculture and nonagriculture will lead to about a 0.22 percent decline in the share of household labor time spent on nonagricultural activities, while a 1.00 percent increase in household capital input available per working unit will be associated with a 0.10 percent increase in the share of household labor time allocated to nonfarming. A 1.00 percent improvement in the state of infrastructure will lead to a 0.21 percent increase in the share of household labor time allocated to nonagricultural activities.[7]

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[7] The elasticity estimates are computed at the mean values of variables.

These findings suggest that policy actions to improve the state of infrastructure and to develop the rural capital and product markets need to be considered if rural households in the Zairian Basin are to divert more of their labor time to farming and other income-generating activities. In the medium term, there is a need to improve the practicability of the existing road network and the navigability of the rivers and to stimulate the trucking, distribution, and marketing of farm implements and products. In the long run, actions to develop rural capital and credit markets should be initiated. These actions should be associated with policy measures designed to generate and promote the diffusion of appropriate agricultural technologies. This will help to improve the volume and the composition of agricultural capital input available to households.

6

ALLOCATION AND USE OF AGRICULTURAL LABOR TIME

The survey shows that the nonagricultural sector, which is the main sector of the rural economy in the Zairian Basin, claimed 75.7 percent of labor time expended on the production of goods and services, while agriculture received only 24.3 percent. The nonagricultural sector produces a variety of goods including game meat, fish, nuts, oil, fruits, leaves, insects, mushrooms, honey, and crafts. Collecting output data on most of these products during the survey proved to be a difficult task. Most of these goods are food commodities, and a substantial fraction of their output is quickly consumed as soon as they arrive in the home. Farmers in the area do not weigh their products. Because of this limitation, the remaining chapters of the study are restricted to labor division, allocation, and use in the farm sector of the rural household economy of the Zairian Basin.

More specifically, this chapter describes the division of agricultural labor between male and female members of the household and examines the pattern of labor allocation between different farm operations in order to delineate these operations on the basis of their claim on male and female labor time allocated to agriculture. This exercise is important on several grounds. First, it will help, in the process of mechanization of the farm sector, to direct effort toward those farm operations that are more labor-consuming and likely to suffer from labor shortages in this land-surplus, labor-scarce economy. Second, it will indicate, for each specific type of mechanization, the target household members. That is, for farm operations predominantly performed by males, efforts to mechanize these operations will be directed to this group and likewise for those operations handled mainly by females. Third, the analysis will also help in the diffusion of improved agricultural techniques for land preparation, planting, fertilizer use, weeding, harvesting, transporting, processing, storage, and marketing of farm produce by targeting the appropriate household members.

Finally, an assessment is made of the intensity of labor use per hectare of cultivated area in the Zairian Basin, and the determinants of this intensity of labor use are identified. This analysis has serious policy relevancy, as the productivity of labor is affected not only by crop yield but also by the intensity of labor use per hectare of cultivated area.

Main Farm Activity in the Study Area

In the Zairian Basin, shifting cultivation of cassava, plantain, rice, and maize is the main farm activity. However, this does not mean that all the labor and other inputs allocated to agriculture in this area are used for this purpose; minor crops such as vegetables and fruits are also produced. For the purpose of the study, it is assumed that labor and other productive inputs allocated to farming are used up in the production of the four major crops.

Cassava is the main staple food consumed by farm households in the study area. Plantain is sold to the Lokele, an ethnic group who specialize in fishing and commerce and whose staple food is plantain. Maize is mostly produced as a raw material used in the production of alcoholic drinks. The survey found that 93.5 percent of the study households who produced maize transformed most of it into alcohol, while 6.5 percent of these households did not process their maize output into alcohol at all. Farmers affirmed that the production of alcohol allows them to turn maize production into a more profitable activity.[8] Rice is mainly produced for sale.

As to the contribution of each crop to total food-crop output, in 1982/83 cassava accounted for 85.0 percent (expressed in kilograms of cereal-equivalents), rice for 7.7 percent, maize for 5.2 percent, and plantain for 2.1 percent. Clearly, the smallholder sector in the Zairian Basin is a cassava-based system.

Division and Allocation of Labor among Farm Operations

In the Zairian Basin, smallholder agriculture is characterized, among other things, by a net division of agricultural labor between male and female members of the household. During land preparation, slashing and burning are primarily performed by men, with a negligible contribution from women, while clearing is mainly undertaken by women, with a substantial contribution from men. During production operations, planting and weeding are handled mostly by females, with a limited contribution from males, whereas the protection of rice from birds is almost solely performed by males. Postproduction operations, including harvesting, transporting, and marketing, are primarily done by women, with a very limited contribution from men.

The allocation of labor time among different farm operations by both male and female household members in the Zairian Basin in 1982/83 is shown in Table 7. The data indicate that most of the male workload was concentrated on land preparation. About 66.5 percent of male labor time devoted to agriculture was allocated to this operation, compared with 5.8 percent of female labor. As for production operations, males allocated 23.1 percent of their farm labor to these operations, compared with 42.1 percent for females. Postproduction operations accounted for only 10.4 percent of male farm labor, whereas females allocated 52.1 percent of their farm labor to the same operations.

This analysis shows that the contribution of male members of the household to agricultural labor time is substantial. This contribution is especially critical in the Zairian Basin, where the size of cultivated area, which is the main determinant for volume of agricultural output, is primarily determined by the amount of male labor time allocated to land preparation.[9] Hence, males in the study area cannot be consid-

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[8] The production of alcoholic drinks at the household level is prohibited by law in Zaire, but this prohibition is not effectively enforced.

[9] This is true because the area has abundant land, and the use of yield-increasing technologies is not known (Tshibaka 1989).

Table 7—Division and allocation of labor by farm operations, 1982/83

Farm Operations	Males		Females		Average for Males and Females	
	Hours per Working Unit[a]	Percent	Hours per Working Unit[a]	Percent	Hours per Working Unit[a]	Percent
Land preparation	171.82	66.46	15.81	5.81	84.70	31.82
Slashing	161.64	62.52	3.40	1.25	73.73	27.70
Burning	2.55	0.99	0.45	0.16	1.33	0.50
Clearing	7.63	2.95	11.96	4.40	9.64	3.62
Production operations	59.82	23.14	114.67	42.12	88.18	33.13
Planting or sowing	46.97	18.17	85.00	31.22	66.25	24.89
Weeding	5.64	2.18	28.35	10.41	18.74	7.04
Protecting rice from birds	7.21	2.79	1.32	0.49	3.19	1.20
Postproduction operations	26.89	10.40	141.78	52.07	93.30	35.05
Harvesting and transporting	19.96	7.72	126.70	46.53	82.01	30.81
Processing and marketing	6.93	2.68	15.08	5.54	11.29	4.24
All operations	258.53	100.00	272.26	100.00	266.18	100.00

Source: Based on data from T. B. Tshibaka "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

[a] A working unit is defined as an adult-equivalent.

ered less active as food producers than females, as some studies on Sub-Saharan Africa seem to suggest (Savané 1988; Snyder 1990; Saito 1991).

Intensity of Agricultural Labor Use

The amount of labor use per hectare is one of the key variables expressing the extent of labor use in the farm sector. This variable has serious implications for both the cost and the productivity of labor input. The amount of labor use per hectare of cultivated area was estimated at about 1,717.1 adult-equivalent hours during the 1982/83 crop year. The coefficient of variation of this amount of labor across households was about 64.5 percent. That is, the intensity of labor use varied from 609 to 2,825 adult-equivalent hours per hectare across households.

This amount of labor use per hectare is high compared with other parts of the developing world and is particularly disturbing in an area characterized by low population density, such as the Zairian Basin. For example, Lassiter (1982) reported 822 hours per hectare in the production of sorghum in eastern Burkina Faso, and in the Mumbwa area of Zambia, farmers spent about 568 hours per hectare in the production of maize (Dodge 1977).

The high intensity of labor use per hectare observed in the study area is explained by a number of factors. The amount of labor required for land preparation is generally high where shifting cultivation is the prevailing mode of production. This labor requirement is further exacerbated when shifting cultivation is practiced in a rain forest zone like the Zairian Basin. Since this mode of production is associated with fallowing, the length of the fallow period is likely to affect the amount of labor required per hectare to slash, burn, and clear the land. The intensity of labor use is also affected by the type of tools used to perform different farm operations such as land preparation, planting, weeding, harvesting, processing, and transporting.

Intensity of labor use is also a function of the type of crop mix. The most prevalent cropping method in the study area is mixed cropping, and the survey was able to distinguish two types: one based on cassava and plantain, the other on rice and maize. It is clear that, other things being the same, the labor requirement per hectare will be different for each type of crop mix. This will be particularly true for the amount of labor time allocated to crop-specific operations such as planting, weeding, scaring birds, harvesting, processing, transporting, and marketing.

Another factor that has a bearing on the intensity of labor use is the timing of different farm operations. The survey found that 32.6 percent of the 132 study households did not follow the recommended agricultural calendar. For example, a late slashing of forest or fallow will not allow the debris and tree branches to dry properly. This will result in a poor burn. A poor burn means that time has to be spent cutting over, stacking, and reburning the remaining plant debris. More branches and logs on the ground will impede planting, weeding, and harvesting. Furthermore, a poor burn does not inhibit weed growth, hence leads to extra labor for weeding. Thus a late slashing of forest or fallow resulting in a poor burn is likely to affect the productivity of labor in two ways—by reducing crop yield and by increasing the intensity of labor use per hectare.

It is also expected that the better a location is connected to markets through a good road network and transportation system, the more labor time farmers will allocate to each hectare of cultivated area in order to produce a good harvest. Therefore, the state of the infrastructure is expected to positively affect the amount of labor time allocated to farming per hectare. Furthermore, farmers tend to allocate more labor time to farming as the farmgate terms of trade between farm and nonfarm products improve. Hence the farmgate terms of trade between farming and nonfarming is also expected to positively affect the intensity of labor use per hectare. Moreover, the amount of labor use per hectare is also expected to be positively affected by the size of the labor force available in the household.

The relationship between the intensity of labor use per hectare and the above variables can be formally expressed as follows:

$$L/A = f(W/A, K/A, T_{an}, I, T, X, F_a, e), \qquad (15)$$

where

L/A = intensity of labor use in adult-equivalent hours per hectare;

W/A = number of working units per hectare expressing the size of the labor force;

K/A = capital input per hectare in zaires per hectare;

T_{an} = farmgate terms of trade between farm products and nonfarm products;

I = state of infrastructure;

T = dummy for timing (1 for households that observed correct timing; 0 otherwise);

X = dummy for crop mix (1 for mix based on rice and maize; 0 for mix based on cassava and plantain);

F_a = dummy for the length of the fallow period (1 for fallows of seven years or more; 0 otherwise); and

e = error term.

A least squares method applied to the survey data provides the results summarized in Table 8. The regression equation shows that the fit is fair and the F-statistic is highly significant at the 1 percent level. All the regression coefficients have the expected signs. The regression coefficients for the type of crop mix (X), the length of the fallow period (F_a), and the capital input per hectare (K/A) are not significantly different from zero. The regression coefficients for timing (T), terms of trade between farming and nonfarming (T_{an}), infrastructure (I), and the size of the labor force (W/A) are statistically significant at the 1, 5, 10, and 10 percent levels, respectively.

The estimate of the elasticity of the intensity of labor use per hectare is about –0.51 with respect to timing, 0.26 with respect to farmgate terms of trade between farming and nonfarming, 0.08 with respect to the state of infrastructure, and 0.04 with respect to the size of the labor force per hectare of cultivated area. This analysis shows that the timing of farm operations and the farmgate terms of trade between farming and nonfarming—and to a limited extent the state of infrastructure and the size of the household labor force available per hectare of cultivated area—are the main determinants of labor use per hectare of cultivated area in the Zairian Basin.

It is particularly important to stress the effect of timing on the intensity of labor use per hectare. As can be seen from this analysis, a 1.00 percent increase in the number of households observing the appropriate timing of farm operations will result in a 0.51 percent decline in the amount of labor use per hectare of cultivated area. It follows that efforts to encourage farmers to observe the recommended agricultural calendar will result in a significant payoff, as the amount of labor use per hectare has a bearing on both the cost and the productivity of labor input.

Table 8—Regression results for the determinants of intensity of labor use per hectare of cultivated area

Explanatory Variables and Important Statistics	Dependent Variable, (L/A)
	(adult-equivalent hours/hectare)
Intercept	1,679.52 (4.83)***
W/A	7.66 (1.43)*
K/A	0.47 (0.85)
T_{an}	233.52 (2.16)**
I	331.51 (1.84)*
T	−1,245.20 (−6.89)***
X	101.33 (0.63)
F_a	182.05 (1.12)
$\bar{R}^2$	0.38
F	12.70
n	132

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: The numbers in parenthesis are t-values. W is the size of the labor force, K is capital input, A is the cultivated area, T_{an} is the farmgate terms of trade between farming and nonfarming, I is the state of infrastructure, T is the timing of farm operations, X is the type of crop mix, and F_a is the age of the fallow. The mean value of the intensity of labor use (L/A) is about 1,717.1 adult-equivalent hours per hectare, with a standard deviation of 1,108.2 adult-equivalent hours per hectare. The capital input per hectare of cultivated area is about 175.4 zaires per hectare, with a standard deviation of 144.8 zaires per hectare. The terms of trade between farm and nonfarm products (producer price of food crops/producer price of palm wine) is about 1.9 liters of palm wine per kilogram of cereal-equivalent with a standard deviation of 0.8 liters of palm wine per kilogram of cereal-equivalent. The average size of the labor force per hectare is about 8.7 working units per hectare with a standard deviation of 15.3 working units per hectare. The mean value for the dummy representing the infrastructure is about 0.4 with a standard deviation of 0.5. For the dummies representing the type of crop mix and the length of the fallow period, the mean values are 0.5 and 0.6 with standard deviations of 0.5 and 0.5, respectively. For the dummy representing the timing, the mean value is 0.7 with a standard deviation of about 0.5.

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.

7

LABOR AND CULTIVATED AREA

In a situation where land is abundant relative to labor and capital, and use of yield-increasing technologies is limited, expansion of cultivated area is the main source of food and agricultural growth. This situation depicts most parts of Sub-Saharan Africa, and the Zairian Basin in particular. In fact, the economic history of Zaire since 1960 suggests that technological change in smallholder agriculture is not going to improve in the foreseeable future unless some drastic changes in policy are initiated (Tshibaka 1986).

Even if the current political changes succeed and lead to fundamental changes in policies and in the management of the economy, expansion of cultivated area is likely to remain, in the medium term, the key determinant of production growth in smallholder agriculture. The relationships between labor use, timing, and cultivated area are examined in this chapter.

Model

Since land is abundant and freely accessible in the Zairian Basin, the size of cultivated area can be considered as a function of capital input, the amount of labor time allocated to land preparation, and the timing of this farm operation. Formally, this postulate can be written as follows:

$$A = f\,(L_{mp}, L_{fp}, K_t, T, D, e), \tag{16}$$

where

A = size of cultivated area,
L_{mp} = male labor time allocated to land preparation,
L_{fp} = female labor time allocated to land preparation,
K_t = capital-tools input spent on land preparation,
T = dummy for timing of land preparation,
D = dummy for locational differences, and
e = error term.

From this construction, it is expected that the size of cultivated area will be positively related to labor and capital inputs. But these explanatory variables cannot be expected to be independent of each other. The amount of female labor allocated to land preparation is expected to increase with declining male participation in land preparation and vice versa. As all the tools (hatchets and cutlasses) used for land preparation are hand-held, a high degree of correlation is expected between this input and the labor time allocated to land preparation.

Finally, the cultivated area is expected to be positively affected by the timing of land preparation. A late slashing of forest or fallow is expected to constrain the household members to reduce the size of cultivated area in order to cope with subsequent farm operations such as burning and clearing.

Definition of Variables

As stated above, the model relates the size of cultivated area (A), expressed in ares,[10] to the following inputs: male (L_{mp}) and female (L_{fp}) labor time in adult-equivalent hours devoted to land preparation, and capital-tools (K_t) input, expressed in zaires, allocated to land preparation. In addition, a dummy variable (T) is used to express the effect of timing on the size of the cultivated area. This variable displays a value of one for all the households that observed correct timing, and zero otherwise. To account for locational differences among the six study sites that form the study area, another dummy variable is used. This dummy displays a value of one for the location of concern, and zero for any other location.

The main statistics describing the dependent and some explanatory variables are presented in Table 9. These data show that an average rural household cultivated less than 1 hectare of land during the 1982/83 crop year. This cultivated area varies between 0.25 and 1.09 hectares, with an average of 0.67. More specifically, the cultivated land area varies by a factor of 4.4 across households.

Table 9—Statistical description of variables for cultivated area, labor for land preparation, and capital

Variable	Mean	Standard Deviation	Coefficient of Variation	Definition
A	67.15	41.86	62.34	Cultivated area per household (in ares)[a]
L_{mp}	283.27	152.14	53.71	Male labor time allocated to land preparation (in adult-equivalent hours)
L_{fp}	31.80	45.80	144.03	Female labor time allocated to land preparation (in adult-equivalent hours)
K_t	75.40	55.49	73.59	Capital-tools input used (in zaires)

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

[a] One are = 100 square meters.

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[10] One are equals 100 square meters.

Specification of the Regression Equation

The capital input allocated to land preparation in the Zairian Basin is mostly made up of hand-held tools (hatchets and cutlasses). As a result, this variable is highly correlated with labor input. To account for this correlation, the theoretical model postulated above is transformed as follows:

$$\frac{A}{K_t} = f\left(\frac{L_{mp}}{K_t}, \frac{L_{fp}}{K_t}, T, D, e\right). \tag{17}$$

A Leontief-Diewert specification, which requires that quadratic and interaction terms be included, was applied to the survey data. As documented earlier, the timing of different farm operations such as land preparation affects the amount of labor used. Therefore, the full specification to be estimated is given by

$$\frac{A}{K_t} = a_o + a_1\left(\frac{L_{mp}}{K_t}\right) + a_2\left(\frac{L_{fp}}{K_t}\right) + a_3\left(\frac{L_{mp}}{K_t}\right)^2 + a_4\left(\frac{L_{fp}}{K_t}\right)^2 + a_5 T + a_6\left(\frac{L_{mp}}{K_t}\right)\left(\frac{L_{fp}}{K_t}\right)$$

$$+ a_7\left(\frac{L_{mp}}{K_t}\right)(T) + a_8\left(\frac{L_{fp}}{K_t}\right)(T) + \sum_{i=1}^{n} b_i D_i + e, \tag{18}$$

where D_i is the dummy representing location i, with i = 1,2,3 ...., n, so that n = k−1 where k = number of study locations. All other variables have their previous meanings.

Regression Results

The ordinary least squares method applied to the survey data provides the regression results summarized in Table 10. The regression equation has a very good fit and the F-statistic is highly significant at the 1 percent level. The regression coefficient for the male labor per capital variable (L_{mp}/K_t) and for its quadratic term are positive and statistically different from zero. The coefficient for the female labor per capital variable (L_{fp}/K_t) is positive and not statistically different from zero. The regression coefficient for the female labor quadratic term is positive and statistically different from zero. The regression coefficient for the male-female labor interaction term is negative and statistically significant at the 1 percent level. This indicates that male and female labor are substitutes in production.

With respect to timing (T), the regression analysis shows that the coefficient for the dummy variable representing this variable is positive and highly significant at the 1 percent level. This implies that correct timing of land preparation affects positively the size of cultivated area. The coefficient for the male labor per capital-timing interaction term (L_{mp}/K_t) (T) is positive and statistically insignificant.

With respect to the interaction between timing and female labor per capital input (L_{fp}/K_t) (T), the regression coefficient is positive and highly significant at the 1 percent level. This finding can be interpreted to mean that correct timing of land preparation leads females to allocate more labor time to land preparation, and this

Table 10—Determinants of cultivated area

Explanatory Variables and Important Statistics	Dependent Variable: Cultivated Area/Capital Input (AK_t)
	(ares/zaire)[a]
Intercept	$(9.96)10^{-4}$ (1.02)
L_{mp}/K_t	$(12.46)10^{-4}$ (6.34)***
L_{fp}/K_t	$(-8.49)10^{-4}$ (-0.98)
$(L_{mp}/K_t)^2$	$(0.08)10^{-4}$ (2.48)**
$(L_{fp}/K_t)^2$	$(8.97)10^{-4}$ (4.76)***
T	$(30.76)10^{-4}$ (3.19)***
$\left(\frac{L_{mp}}{K_t}\right)\left(\frac{L_{fp}}{K_t}\right)$	$(-2.85)10^{-4}$ (-5.91)***
$\left(\frac{L_{mp}}{K_t}\right)(T)$	$(1.80)10^{-4}$ (0.96)
$\left(\frac{L_{fp}}{K_t}\right)(T)$	$(31.99)10^{-4}$ (3.18)***
Dummies for location	
D_1	$(-1.14)10^{-4}$ (-0.10)
D_2	$(4.05)10^{-4}$ (0.38)
D_3	$(26.67)10^{-4}$ (2.65)
D_4	$(-11.27)10^{-4}$ (-1.24)
D_5	$(-13.05)10^{-4}$ (-1.51)
$\bar{R}^2$	0.91
F	96.58
n	130

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: L_{mp} stands for male labor time in adult-equivalent hours allocated to land preparation, L_{fp} for female labor time in adult-equivalent hours devoted to the same operation, K_t for capital tools, T for a dummy accounting for timing of land preparation, and D for a dummy accounting for locational differences.

[a] One are = 100 square meters.

* Significant at the 0.10 level.

** Significant at the 0.05 level.

*** Significant at the 0.01 level.

affects positively the size of cultivated area. With regard to locational differences, the analysis suggests that these differences are negligible.

The elasticity estimate of the area-capital ratio is 0.73 with respect to the male labor-capital ratio and 0.11 with respect to the female labor-capital ratio. This implies that a 1.00 percent increase in male labor will be associated with a 0.73 percent increase in cultivated area, while a 1.00 percent increase in female labor will lead to about a 0.11 percent increase in cultivated area.

With respect to timing, the elasticity estimate of the area-capital ratio with respect to this variable is about 0.49. This suggests that a 1.00 percent increase in the number of households observing correct timing of land preparation will lead to a 0.49 percent upward shift in the curve describing the cultivated area function. It is useful to note that only 67.4 percent of the 132 study households observed correct timing during the 1982/83 crop year.

From this analysis, it can be concluded that the amount and timing of male labor time allocated to land preparation are the key factors affecting the size of cultivated area in the Zairian Basin.

8

LABOR AND AGRICULTURAL OUTPUT

This chapter establishes the relationship between the volume of farm output, the amount of labor time, and the timing of farm operations in order to estimate the contribution of male and female labor time to agricultural production and to examine the effects of timing on farm output and labor productivity.

Production Function Analysis

Model

Since land is not a binding constraint in the Zairian Basin, the farm output in this area can be regarded primarily as a function of labor and capital input. The timing of farm operations as well as the type of crop mix used also affects the volume of farm output. The observed variations in the volume of farm output are also explained by the level of soil fertility and by locational differences among study locations.

A Cobb-Douglas transformation with constant returns to scale was chosen to estimate the structural parameters describing the agricultural production function in the study area. More clearly, the following Cobb-Douglas production function is estimated:

$$\ln Q = \ln c + \alpha_1 \ln L_m + \alpha_2 \ln L_f + \alpha_3 \ln K + \beta_1 T + \beta_2 X + \beta_3 F_a + \sum_{i=1}^{n} \varepsilon_i D_i + e \qquad (19)$$

where

Q = farm output,
c = intercept or constant term,
L_m = male labor time,
L_f = female labor time,
K = capital input,
T = dummy for timing,
X = dummy for crop mix,
F_a = dummy for length of fallow period
D_i = dummy for study location ($i = 1,2,\ldots,n$; so that $n = k-1$ where k = number of study locations), and
e = error term.

A positive relationship is expected between the volume of farm output, labor, and capital. The volume of farm output is also expected to be positively related to the length of the fallow period. An improvement in the timing of different farm operations is expected to be associated with an upward shift in the production curve. Since cassava and plantain are more productive than maize and rice in calories per unit of land, it is expected that a cropping mix based on cassava and plantain will lead to an upward shift in the production curve, while a mix based on rice and maize will be associated with a downward shift.

Definition of Variables

The volume of agricultural output is expressed in kilograms of cereal-equivalents, labor time in adult-equivalent hours, and capital input in zaires. For the level of soil fertility, the length of the fallow period is used as a proxy. This variable is expressed as a dummy, which assumes a value of one for a fallow of seven years or more, and zero otherwise. Therefore, the regression coefficient for the dummy fallow is expected to be positive.

For the timing of farm operations, a dummy expressing this variable is given a value of one for households that observed the recommended agricultural calendar and zero for other households. The regression coefficient for timing is expected to display a positive sign. With respect to cropping mix, a dummy displaying a value of one is used for a mix based on rice and maize, and zero for a mix based on cassava and plantain. For the reason advanced above, the coefficient for the cropping mix is expected to be negative.

The main statistics for the dependent and explanatory variables used in estimating the farm production function are described in Table 11. The data show that an average household in the Zairian Basin produced about 2,539 kilograms of cereal-equivalents in 1982/83, representing 423 kilograms of cereal-equivalents per capita or 686 kilograms of cereal-equivalents per working unit. Male members of an average household contributed about 426 hours of work to farming and females provided about 564 hours. An average household had, during the study year, about 3.7 working units, of which 1.6 were male and 2.1 were female. The capital input allocated to farming was about 100.7 zaires, representing at that time about US$17.52.

Table 11—Statistical description of variables for total output, labor, and capital

Variable	Mean	Standard Deviation	Coefficient of Variation	Definition
			(percent)	
Q	2,539.31	2,183.95	86.01	Farm output (in kilograms of cereal-equivalents)
L_m	426.24	254.41	59.69	Male labor to farming (in adult-equivalent hours)
L_f	563.89	385.69	68.40	Female labor to farming (in adult-equivalent hours)
K	100.74	68.80	68.29	Capital (tools and seeds) input to farming (in zaires)

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Regression Results

An ordinary least squares method applied to the survey data provides the regression results described in Table 12. The regression equation shows that the fit is good and the F-statistic is highly significant at the 1 percent level. All the regression coefficients display the expected signs and are statistically different from zero at the

Table 12— Regression results for the farm production function

Explanatory Variables and Important Statistics	Dependent Variable ($\ln Q$)
$\ln e$	1.92 (3.89)***
$\ln L_m$	0.44 (4.41)***
$\ln L_f$	0.34 (3.92)***
$\ln K$	0.16 (2.24)**
X	−0.42 (−4.27)***
T	0.47 (4.52)***
F_a	0.01 (0.14)
Dummies for location	
D_1	−0.07 (−0.37)
D_2	−0.63 (−3.26)***
D_3	−0.15 (−0.85)
D_4	0.66 (3.86)***
D_5	0.34 (2.42)**
$\bar{R}^2$	0.73
F	32.43
n	132

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: Output for all crops (Q) combined—rice, maize, cassava, and plantain—is expressed in kilograms of cereal-equivalents using the following conversion factors: 1.00 for maize kernels, 0.60 for paddy rice, 0.303 for fresh cassava tubers, and 0.220 for plantain. L_m and L_f are male and female labor time allocated to agriculture, K is capital input; X, T, and F_a are dummies representing the type of crop mix, the timing of farm operations, and the age of the fallow period, respectively.

** Significant at the 0.05 level.

*** Significant at the 0.01 level.

1 and 5 percent levels. Locational differences are not negligible. These results suggest that the above explanatory variables are the main determinants of farm output in the Zairian Basin.

The elasticity estimate of farm output (Q) is 0.44 with respect to male labor time (L_m), 0.34 with respect to female labor time (L_f), and 0.16 with respect to capital input (K). Since the sum of these elasticity estimates is statistically equal to 1.00, which implies constant returns to scale, these output elasticities are also the factor shares, representing the contribution of individual inputs to farm output.

The elasticity estimate of the farm output with respect to the type of crop mix is about –0.42, indicating that, other things being the same, a 1.00 percent increase in the number of households using a rice-maize cropping mix will be associated with a 0.42 percent downward shift in the farm production curve. The elasticity estimate of the farm output with respect to the timing of farm operations is about 0.47 percent, implying that a 1.00 percent increase in the number of households observing correct timing of farm operations will be associated with a 0.47 percent upward shift in the farm production curve.

The analysis indicates that the type of cropping mix and the timing of farm operations are important shifters affecting the farm production curve. With regard to farm inputs, male labor, followed by female labor, and then capital are the main production inputs in the Zairian Basin.

Labor Productivity

On the basis of the above regression equation depicting the farm production function, the average and marginal products of labor input are estimated for the entire sample and summarized in Table 13. The average and marginal products of male labor time are 34.3 and 74.1 percent higher, respectively, than those of female labor

Table 13— Average and marginal products of labor input, 1982/83

Variable	Mean	Standard Deviation	Coefficient of Variation
			(percent)
Average product of labor (kilograms of cereal-equivalents/hour)			
Males	6.89	7.35	106.68
Females	5.13	3.70	72.12
Males and females	2.61	1.79	68.58
Marginal product of labor (kilograms of cereal-equivalents/hour)			
Males	3.03	3.23	106.60
Females	1.74	1.26	72.41
Males and females	2.04	1.40	68.63

Source: Based on data from T. B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

time. In addition, the average products of labor time allocated to farming are larger than their respective marginal products. This tends to suggest that both males and females operate in the rational or second phase of production. This phase corresponds to an optimum use of labor input.

Furthermore, the productivity of labor exhibits a high degree of variability across households. The coefficient of variation for the productivity (average or marginal product or both) of male and female labor combined is about 68.6 percent. Put differently, the average product of labor time allocated to farming by males and females combined varies from 0.8 to 4.4 kilograms of cereal-equivalents per hour of work. The marginal product of the same input varies from 0.6 to 3.4 kilograms of cereal-equivalents per hour of work. This means that the productivity (average or marginal product or both) of labor allocated to farming in the Zairian Basin varies by a factor of about 6 across households.

Another interesting question to examine is how the productivity of agricultural labor in the Zairian Basin compares with that of labor in other rural areas of the Sub-Saharan region. Table 14, which is drawn from this and other studies, provides some insights.

First, the productivity of labor allocated to the production of a given crop varies greatly across and within agro-ecological zones. For example, the average product of labor in rice production in The Gambia was found to be about 1.62 kilograms of cereal-equivalents per man-hour. In Sierra Leone, the same parameter exhibits a value of about 0.96 kilograms of cereal-equivalent per man-hour. It should be stressed that the production of rice in these countries uses the same production techniques. The observed differences can be ascribed to a large extent to differences in the intensity of labor use in rice production in the two countries. Since the productivity of labor is determined by the level of crop yield and the intensity of labor use, a high intensity of labor use depresses the level of labor productivity. The intensity of labor use in the production of rice in Sierra Leone, a humid area, is about 79.8 percent greater than in the production of rice in The Gambia, a Sahelian zone. As can be seen from Table 14, the intensity of agricultural labor use in the humid zones of Sub-Saharan Africa is generally much greater than in the Sahelian and subhumid zones. The reasons for this relatively high labor intensity in the humid zones are documented in Chapter 6. Table 14 also shows that the productivity of labor varies substantially within the same agro-ecological zone. This variability can be ascribed to some extent to differences in production technology and crop mix.

Second, the estimate of the average product of labor in the Zairian Basin remains within the range observed in the Sub-Saharan region, while the estimate of the marginal product of the same input appears to be relatively high. This estimate remains, however, in the acceptable range, particularly when compared with the estimate of the average product of labor derived from the same sample. Most estimates of the marginal product of labor derived from other studies and reported in Table 14 are substantially lower than those for the average product, and in some cases they are close to zero. Since land in the Zairian Basin is abundant relative to labor, the marginal product of the agricultural labor must exhibit a value that is substantially greater than zero. The estimate of the marginal product of labor derived in this study confirms this economic principle. The areas where the other studies were conducted are relatively more populated than the Zairian Basin.

Table 14—Comparison of intensity and productivity of labor allocated to farming in Zairian Basin with other areas of Sub-Saharan Africa

Area/Country/Year	Agroecological Zone	Crops Studied	Intensity of Labor Use	Average Product of Labor	Marginal Product of Labor
			(hours/hectare)	(kilograms of cereal-equivalents/hour)	
Eastern Burkina Faso, 1978	Sahel	Sorghum and millet	618.00	0.88	0.88
The Gambia, 1985-87	Sahel	Rice	1,310.70	1.62	0.39
The Gambia, 1985-87	Sahel	Maize, sorghum, and millet	452.64	1.69	1.25
Darwin, Zimbabwe, 1963	Subhumid	Maize	324.00	7.50	1.25
Cheweshe, Zimbabwe, 1963	Subhumid	Maize	144.00	3.67	0.53
Sierra Leone, 1979	Humid	Rice	2,356.00	0.96	. . .
Zairian Basin, Zaire, 1991	Humid	Cassava, rice, maize, and plantain	1,717.10	2.61	2.04

Sources: Data for eastern Burkina Faso and for Darwin and Cheweshe in Zimbabwe are based on J. Mellor, C. Delgado, and M. Blackie, eds., *Accelerating Food Production in Sub-Saharan Africa* (Baltimore, Md., U.S.A.: Johns Hopkins University Press for the International Food Policy Research Institute, 1987); for The Gambia, data are computed from J. von Braun et al., *Structural Adjustment, Agriculture, and Nutrition: Policy Options in The Gambia*, Working Papers on Commercialization of Agriculture and Nutrition 4 (Washington, D.C.: International Food Policy Research Institute, 1990); for Sierra Leone, data are computed from P. Matlon et al., *Poor Rural Households, Technical Change and Income Distribution in Developing Countries: Two Case Studies from West Africa*, African Rural Economy Paper 29 (East Lansing, Mich., U.S.A.: Michigan State University, Department of Agricultural Economics, 1979); and for the Zairian Basin, data are from Table 13 of this report.

Note: Massell and Johnson (1968) found that in Zimbabwe, smallholder farmers allocate 4.5-7.0 hours to agriculture per day of work. Some other researchers report fewer hours allocated to agriculture per day of work. In the Uboma area of Nigeria, Oluwasanmi et al. (1966) report that an average male devotes 3.4 hours to farming per day of work, while his female counterpart spends about 2.4 hours. However, it is generally assumed that a smallholder farmer in Sub-Saharan Africa spends on average 6.0 hours on agriculture per day of work. Using this rough estimate, the data reported by these researchers are transformed and summarized here. It is, however, important to note that the above estimates of labor productivity come from very diverse studies. These studies did not necessarily use the most appropriate methods of data collection, the same specification of the production function, or the same definitions of the dependent and explanatory variables (for example, expressing labor in man-days instead of hours of work; a man-day of farm work has been found to vary between 2.4 and 7.0 hours of work per day). For these reasons, it appears difficult to make a firm judgment about the comparability of the estimates of average and marginal productivities of labor derived from these studies and those computed in the present study.

Effect of Timing on Farm Output and Labor Productivity

The interhousehold variation in the average and marginal products of labor observed in the study area suggests that some improvement in labor productivity can be achieved with the current resource base and technology available to rural households in the area. In fact, the above regression analysis shows that, without additional resources, the adoption of the recommended agricultural calendar by most households will have a positive and significant effect on the volume of farm output, and hence on productivity of labor and other farm inputs.

A critical observation of the different farm fields during the survey indicates that a substantial number of farmers did not follow the recommended agricultural calendar. As a result of inappropriate timing, land preparation, planting, weeding, and harvesting were not only poorly performed but also claimed more labor time than they would have with proper timing. The execution of some of these operations was extended beyond the recommended period. This inappropriate timing resulted in both increased labor use per hectare and reduced crop yield, and hence in reduced farm output and labor productivity.

The study analysis of course confirms this observation. Assuming that, other things being the same, all the sample households are led to observe the recommended agricultural calendar, what will be the effect on farm output and labor productivity? To answer the question, the sample was divided into two groups, and the amount of farm output was estimated for all the households that did observe correct timing of farm operations. The same exercise was repeated for the other group of study households. These results are shown in Table 15.

It appears from this analysis that if the households that did not observe the recommended agricultural calendar are persuaded to adopt correct timing, their farm output will increase on average by 41.5 percent, and the farm output for the entire sample will increase by about 10.6 percent. The average and marginal products of labor were computed for households that observed the recommended agricultural calendar as well as for those that did not. The data reveal that the average and marginal products of labor for households that did not observe correct timing can be increased by about 60.0 percent. For the entire sample, this increase in labor productivity is about 14.0 percent.

This potential gain in farm output and labor productivity cannot be ignored. Therefore, farmers should be encouraged to observe the recommended agricultural calendar. It follows that efforts to improve extension services are also needed.

Table 15—Effect of timing on household farm output and labor productivity, 1982/83

Household Observation of Timing	Number of Households	Average Volume of Farm Output	Potential Gain in Farm Output	Average Product of Labor	Potential Gain in Average Product of Labor	Marginal Product of Labor	Potential Gain in Marginal Product of Labor
	(percent)	(kilograms of cereal-equivalents/household)	(percent)	(kilograms of cereal-equivalents/hour)	(percent)	(kilograms of cereal-equivalents/hour)	(percent)
Households that observed the recommended timing	67.42	2,807.49	0.00	2.97	0.00	2.32	0.00
Households that did not observe the recommended timing	32.58	1,984.24	41.49	1.86	59.68	1.45	60.00
All sample households	100.00	2,539.31	10.56	2.61	13.79	2.04	13.73

Source: Based on data from T. B. Tshibaka, "Food Productioni n the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

9

POLICY IMPLICATIONS AND CONCLUSIONS

Labor is the primary production input available to the small-farm sector in most of Sub-Saharan Africa. Increasing the productivity of this resource remains central to both agricultural growth and overall economic growth in the region. Consequently, an in-depth analysis of the labor resource and its related aspects should significantly contribute to agricultural policy formulation. Toward this end, the study examined the division and allocation of household labor time, identified key factors affecting the allocation of this resource among different household activities, conducted a detailed analysis of labor use in the small-farm sector, and examined the productivity of labor input and the contribution of labor to farm output in the Zairian Basin.

The natural population growth rate in the study area is low—about 1.2 percent a year from 1980 to 1983, compared with 2.8 percent for the country as a whole. However, about 42.0 percent of the study sample were under 15 years of age, which means that momentum for future growth in the labor force in the study area is already built into the population.

Division and Allocation of Household Labor Time

Income-generating activities of rural households in the Zairian Basin include farming and nonfarming activities, while non-income-generating activities are made up of domestic, sociocultural, and leisure activities. With respect to farming, slashing and burning of forest land or fallow are primarily done by men, while clearing, planting, weeding, harvesting, transporting, processing, and marketing of produce are mainly undertaken by women. The formulation of policy actions to improve the existing agricultural techniques or to introduce new production techniques and inputs has to take into account this gender division of agricultural labor and its implications for research and extension services.

In the nonfarm sector, hunting, fishing, and gathering nuts from wild palm trees are mostly undertaken by men, whereas gathering food products in the forest and extraction of palm oil are mainly carried out by women. Handicrafts and extraction of palm wine are male activities, while the processing of maize into the local alcoholic drink is done by females. Both men and women engage in petty trade. Regarding non-income-generating activities, domestic work is primarily performed by women. Gardening, building and maintaining houses, health care, schooling, meetings, church services, and other sociocultural activities are jointly performed by men and women. The study data seem to contradict some widely held beliefs that men in rural Africa tend to contribute little to household working time allocated to income-generating and domestic activities.

The allocation of household labor time to agriculture and nonagriculture was found to be mainly determined by the farmgate terms of trade between agriculture and nonagriculture, the level of household capital input available per working unit, and the state of the infrastructure. Specifically with respect to the share of household labor time allocated to agriculture, a 1.00 percent increase in the farmgate terms of trade between agriculture and nonagriculture would be associated with a 0.27 percent increase, a 1.00 percent increase in household capital input per working unit would lead to a 0.26 percent increase, while a 1.00 percent improvement in the state of infrastructure would result in a 0.23 percent increase.

This finding underlines the centrality of both private (household capital input) and public (infrastructure) capital goods in the process of labor allocation and use in the rural household economy. This implies that policy actions to improve the infrastructure and develop the rural capital and product markets need to be considered if rural households in the Zairian Basin are to divert more labor time to farming and other income-generating activities. In the medium term, there is a need to improve the practicability of the existing road network and the navigability of the rivers and to stimulate the trucking, distribution, and marketing of farm implements and products. In the long run, actions to develop rural capital and credit markets should be initiated. These actions should be associated with policy measures designed to generate and promote the diffusion of appropriate agricultural technologies and practices. This will help improve the volume and the composition of agricultural capital input available to households.

Agricultural Labor Use

Cassava, rice, maize, and plantain are the main crops produced in the small-farm sector of the Zairian Basin under a shifting cultivation mode of production. Land is plentiful and freely accessible to every rural household. Capital input is limited to simple hand tools and on-farm crop seeds, and labor input is provided by the household members. By any standards, labor is the main farm input available to the rural households in this area.

In 1982/83, the intensity of labor use varied from 609 to 2,825 adult-equivalent hours per hectare across households, with an average of 1,717 hours. This amount of labor time per hectare is high compared with other parts of the developing world. Efforts to reduce this use of labor will have a positive and significant effect on the cost and productivity of the labor input allocated to agriculture. The analysis indicates that the intensity of labor use per hectare would be greatly reduced if farmers followed the recommended agricultural calendar.

The assessment of the relationship between labor input, timing of land preparation, and cultivated area shows that correct timing of land preparation enables the household to slash and burn and clear a much larger area of land, using the same amount of labor time, than when the timing is inappropriate. The analysis also indicates that the amount of male labor time allocated to land preparation is the main determinant of the size of cultivated area. Furthermore, the analysis suggests that male and female labor are substitutes in production.

The analysis of farm production suggests that the volume of output could be increased by 10.6 percent if all the households observed correct timing of farm operations. About 32.6 percent of the 132 study households were found not to follow appropriate timing. These households could increase their farm output by 41.5 percent if they followed the recommended agricultural calendar. The type of crop mix also affects the volume of output, since cassava and plantain are biologically more productive than rice and maize in terms of energy per unit of land and labor.

Agricultural Labor Productivity

The average and marginal products of agricultural labor in the study are estimated at 2.6 and 2.0 kilograms, respectively, of cereal-equivalents per hour of work. This level of labor productivity is not only low but also exhibits a high degree of variability across households.

It should be stressed that a low level of labor productivity does not mean that the volume of labor and capital inputs cannot be simultaneously increased in order to raise the volume of agricultural output. The study analysis suggests that increased agricultural capital input will stimulate farmers to allocate more labor to farming and consequently to increase the volume of crop output.

This change in the volume of resources and output will not necessarily lead to a change in the productivity of labor or capital input. But the adoption by most farmers of the recommended agricultural technology and practices will significantly and positively affect the productivity of labor and other inputs. For instance, the adoption of the recommended agricultural calendar by most households was found to have a positive and significant effect on labor productivity. In fact, the study indicates that agricultural labor productivity could be increased by about 14 percent if all the households observed the appropriate timing of farm operations.

Conclusions

To increase the volume of farm output and the productivity of labor and other inputs, this study suggests a number of policy measures. In the near future, educating farmers to observe the recommended agricultural calendar will have a significant payoff in terms of increased farm output and productivity. Therefore, efforts to improve research, extension, and weather forecasting need to be seriously considered. This will help develop a sound agricultural calendar. The data show that in 1982/83 the cultivated area per capita was about 0.11 hectare. If all the households observe the presently recommended agricultural calendar, this will result in a 13.7 percent increase in cultivated area. The cultivated area per capita will then increase from 0.11 to 0.15 hectare.

In the medium term, the improvement and expansion of basic infrastructure such as road networks and distribution and marketing channels for farm inputs and products should be pursued in order to stimulate rural households to allocate more resources, including labor, to farming and other income-generating activities. Increased agricultural labor input will ultimately be associated with increased farm output.

In the long run, actions to develop rural capital and credit markets should be initiated. These actions should be associated with policy measures designed to generate and promote the diffusion of appropriate agricultural technologies. This will help improve the volume and composition of agricultural capital input available to rural households.

At first glance, suggesting land expansion in a forest zone runs contrary to current concerns about degradation of the environment. It is even more questionable in the case of the slash-and-burn fallow mode of production that prevails in the study area. To put this issue into context, it has to be noted that two seemingly contradictory objectives are concurrently pursued. These are the growth of the economy and the protection of the environment. Finding a trade-off between these two goals is a matter of serious debate among policymakers and scientists worldwide. In fact, the kind of land expansion contemplated in this study does not represent a serious threat to the environment in the Zairian Basin, a sparsely populated area with fewer than five people per square kilometer.

The tropical rain forest zone represents almost 40 percent of the total land area of Zaire, so the question to be addressed is what type of agriculture should be promoted in this area. From an ecological viewpoint, the tropical rain forest zone is more suitable to perennial (tree) crops than annual (food) crops. Tree-crop agriculture approximates the natural environment by replacing the natural forest with an artificial one composed of trees that produce crops such as palm oil, coffee, cocoa, and rubber. Thus its negative effect on the environment, particularly on soil and forest conservation, is relatively small compared with the shifting cultivation that characterizes the production of annual crops in the study area.

From a long-term standpoint, it is clear that efforts in the Zairian Basin have to be directed toward the promotion of tree-crop production systems and the development of food markets. However, in the short and medium terms, farm households have to produce food crops not only for home use but also for markets in order to generate cash income that could be partly invested in the development of tree-crop production systems and food markets.

It is therefore imperative to increase the farm output and productivity of individual farm households in the near or intermediate future, while relying on the available domestic resources and technology. This is not to say that efforts should not be concurrently initiated to increase both the productivity of labor and the productive capacity of land through use of an appropriate package of technologies, and consequently to preclude any need for shifting cultivation. Research conducted in the humid tropics of Africa indicates that the use of mineral and organic fertilizers coupled with appropriate land management would help achieve this goal.

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R5620-1.35F 10/92

RESEARCH REPORT

91

RURAL INFRASTRUCTURE, THE SETTLEMENT SYSTEM, AND DEVELOPMENT OF THE REGIONAL ECONOMY IN SOUTHERN INDIA

Sudhir Wanmali

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Sudhir Wanmali

Research Report 91
International Food Policy Research Institute

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Library of Congress Cataloging-
in-Publication Data

Wanmali, Sudhir.
Rural infrastructure, the settlement system, and development of the regional economy in Southern India / Sudhir Wanmali.
p. cm. — (Research report / International Food Policy Research Institute ; 91)
Includes bibliographical references.
ISBN 0-89629-094-8
1. Rural development—India—North Arcot. 2. Land settlement—India—North Arcot. 3. Central places—India—North Arcot. 4. Infrastructure (Economics)—Social aspects—India—North Arcot. 5. Human services—India—North Arcot. I. Title. II. Series: Research report (International Food Policy Research Institute) ; 91.

HN690.Z9C6858 1992 92-28423
307.1'412'09548—dc20 CIP

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FOREWORD

How technological change in agriculture contributes to the overall economic development of rural areas has received substantial research attention at IFPRI. One of the major planks of this effort has been the analysis of policies to develop rural infrastructure. Such policies have proven to be important catalysts for successfully transforming subsistence agriculture into commercial agriculture.

Infrastructure analysis has included work on the supply of and demand for rural infrastructure, its effects, and the dynamics of rural infrastructural development in the context of technological change in agriculture. The studies conducted so far have addressed all of these aspects in South Asia but only a few of them in southern Africa, where work continues.

Interdisciplinary analysis of the two regions provides a rich empirical contrast because of differences in socioeconomic conditions and levels of agricultural development. Whereas in South Asia the impact of rural infrastructure on agricultural and rural development has been impressive and positive (see *Service Provision and Rural Development in India: A Study of Miryalguda Taluka,* Research Report 37, *Rural Household Use of Services: A Study of Miryalguda Taluka, India,* Research Report 48, and *Developmental Impact of Rural Infrastructure in Bangladesh,* Research Report 83), a serious lack of rural infrastructure in the smallholder farming regions of southern Africa acts as a major constraint to development in that part of the world (see *Service Provision and Its Impact on Agricultural and Rural Development in Zimbabwe: A Case Study of Gazaland District,* a 1992 occasional paper).

The analysis conducted so far at IFPRI has shown that geographical as well as economic aspects of rural infrastructural development have far-reaching implications. Better road infrastructure, for example, has been shown to influence agricultural production favorably through prices, diffusion of new agricultural technology, and use of inputs. It also improves the incomes of the poor, whether they derive their living from farm or nonfarm activities. IFPRI's work has also shown that provision of services—both public and private—plays a major role in rural development.

In this report, Sudhir Wanmali adds another component to the overall structure of IFPRI's work in this important area of research. The study uses a theoretical framework developed in economic geography to analyze the regional implications for development of access to rural service infrastructure in a southern district of India. It suggests that, by juxtaposing regional and household-level analyses, ways to improve the distribution system in the study region will be evident. This is within the conceptual framework of IFPRI's overarching emphasis on agriculture's role in the development of a region and on access for the rural poor to the producer and consumer goods and services they need to improve their lives.

Per Pinstrup-Andersen

Washington, D.C.

ACKNOWLEDGMENTS

This research report is the product of a collaborative study conducted in North Arcot District of Tamil Nadu, India, by the International Food Policy Research Institute (IFPRI); the Centre for Agricultural and Rural Development Studies of Tamil Nadu Agricultural University, Coimbatore; and by the Department of Geography of the University of Madras, Madras. It is part of a collaborative research program on the future growth in Indian agriculture developed by IFPRI under a memorandum of understanding with the Indian Council of Agricultural Research and with funding from the United States Agency for International Development. The overall objective of the research program, undertaken in collaboration with research institutions and scholars in India, is to contribute toward increased understanding of the options and complexities in the future policies for agricultural growth and development.

I am most grateful to the Director General of IFPRI for his continued interest in this area of research. I have benefited greatly from the suggestions made by my colleagues and friends, which were instrumental in improving the content of this study. Not all can be mentioned, but the following are gratefully acknowledged: Raisuddin Ahmed, Gunvant Desai, B. H. Farmer, Lawrence Haddad, Mahabub Hossain, Dayanatha Jha, C. Ramasamy, A. Ramesh, Joseph E. Schwartzberg, Girish Chandra Srivastava, Timothy Unwin, and Stephen Vosti. None, however, is responsible for the acts of omission and commission in this study.

I am also grateful to Neal Bliven and Jane He for their superb research assistance in preparing this manuscript; without their patience and perseverance, it is no exaggeration to say that this manuscript could not have been completed.

1

SUMMARY

The relationships between rural infrastructure, settlement systems, and regional economic development should distinguish between soft infrastructure (services), institutional infrastructure (government agencies), and hard infrastructure (such as roads). For example, government investment in various types of infrastructure, based on the spatial, economic, and demographic characteristics of regional settlement systems, has encouraged complementary investment by the private sector, leading to overall regional economic development in India.

Once established, the use of services is influenced by the distance between the household and the service, and by the household's net income level. Services are located in settlements that have the capacity to sustain them, but they are also used by people from neighboring settlements. Establishing services in distant towns may be of little help to villagers.

This analysis of the settlement system is undertaken within the framework of Walter Christaller's central place theory, which attempts to explain the distribution of services and service centers in a region based on the functional and demographic characteristics of the settlements of a region. This report analyzes the provision and use of soft infrastructural services in the eastern part of North Arcot District, Tamil Nadu State, India. The area studied consists of 5,508 square kilometers inhabited by approximately 1.6 million people. Data were collected in 1982/83 on 134 types of services located in 535 larger settlements (those with populations greater than 750). In that year, data were also collected from 345 sample households distributed among 11 sample villages. Based on that data, the characteristics of provision and use of soft infrastructural services are noted.

The soft infrastructure considered in this study is divided into nine service categories: education, health, communication, finance, transport, cultivation inputs and implements, animal husbandry, output marketing, and retail services. The services are also classified according to settlement population sizes associated with various services: low order, 48 services, which first occur in settlements with less than 1,000 residents; middle order, 75 services, which first occur in settlements with 1,000-3,500 residents; and high order, 11 services, which first occur only in settlements with more than 3,500 residents. Settlements are themselves categorized by level of service provision, as defined by "centrality" values based on the number and hierarchy of services provided and the population level at which each of these services first occur.

Since service availability is not uniform among all settlements, an attempt is made to categorize settlements as service centers (which provide services to other villages), or self-sufficient settlements, or dependent settlements. If a settlement has more than 50 percent of the services that constitute a given order and provides any of those services to another settlement, then it is considered to be a service center for that order. If only the first criterion is met, the settlement is deemed to be self-sufficient and thus serves only itself. Conversely, a settlement that depends upon any other settlement for more than 50 percent of the services associated with a given order is a dependent settlement. For low-order services, 12 settlements qualified as service centers, but 461 others were self-sufficient. For middle-order services, 17 were service centers, and for high-order services, 12 were service centers.

The provision of services within the subregions served by service centers is also evaluated. By examining a subregion's availability of services (calculated as the ratio of the quotients of the service provision score divided by area served for the subregion and the study region as a whole), it is possible to note whether the subregion is relatively sufficient or deficient in services.

To identify gaps within subregions and those at the settlement level, "entry zones" based on population sizes of the settlements are determined for each service, and settlements that have a larger population than the "zone" but lack the service are noted. Settlements that are deficient in a particular service, but have the necessary population, are considered prime candidates for public and private investment to establish the missing services in the settlement system.

The literature on rural service infrastructure observes that, in addition to population size, access to hard infrastructure such as roads is an important determinant in deciding where to locate soft infrastructural services. This hypothesis is tested using data on the settlement populations and on distances to the nearest bus stop (road transportation infrastructure). Based on statistically significant logit regression results, the effect of isolation from road transportation infrastructure is simulated: if the specified settlement is of average size (say, 1,953 persons), and the nearest bus stop is located 1 kilometer farther away (say 1.7 kilometer instead of 0.7 kilometer), the probability of a service being located in a particular community would be 6 percent rather than 12 percent for a high school, 1 percent rather than 2 percent for a primary health center, 0 percent rather than 2 percent for a post office, 23 percent rather than 25 percent for a telegraph office, 1 percent rather than 2 percent for a lead bank (a bank responsible for coordinating development financing), 7 percent rather than 11 percent for a fertilizer shop, 1 percent rather than 3 percent for a veterinary dispensary, and 3 percent rather than 4 percent for a groundnut market.

A number of household characteristics influence consumer expenditure decisions. However, the most important influences are total per capita expenditure (a proxy for permanent income), distance to the nearest bus service, and accessibility of transport (measured as a percentage of a village's households owning various modes of transport). The hypothesis is tested using two-stage least-squares estimations of modified Working-Lesser variations of Engel functions. The total per capita expenditure instrument is predicted in the first stage. Marginal budget shares of total expenditure are indicated for paddy and nonpaddy farmers. For both average and marginal budget shares, nonpaddy farmers spend more on low-order goods (purchased food and personal items), and paddy farmers spend more on middle-order goods (consumer durables). Within the geographical hierarchy or economic classification of goods and services, households of all four types—paddy farmers, nonpaddy farmers, cultivation laborers, and noncultivators—spend a larger share on low-order goods than on middle-order goods.

Access to rural service infrastructure also has an effect on farmers' use of inputs (supplies of fertilizer, seed, and farm credit): for paddy farmers, an increase of 1 kilometer in distance to credit services decreases spending on fertilizer by Rs 25.97

and a 1-kilometer increase in distance to fertilizer services decreases spending on fertilizer by Rs 24.70. The larger the share of households owning bicycles or motorcycles in a village, the higher the demand for the three inputs.

The demand for output marketing services is also influenced by infrastructure access. A 1-kilometer increase in distance to the nearest output market results in a Rs 124.53 decrease in annual crop marketing revenue for paddy farm-operating households. Access to a bicycle has a positive effect on output marketing.

The findings on regional and locational gaps, population thresholds, and the impact of access to services on household expenditure patterns can be combined to plan a distribution system for producer and consumer services in the study region. For example, since a decrease of 1 kilometer in the distance to the nearest fertilizer shop would increase the farm operating household's fertilizer demand by Rs 24.70, and the median population threshold for fertilizer centers is 5,340 persons, it is recommended that investments in new fertilizer establishments be concentrated in the four settlements of sufficient population size that lack this service, with the aim of serving some of the seven subregions that are deficient in input services.

Notwithstanding the subregional and locational gaps that exist in the distribution systems of goods and services, the study region presently encompasses most of the service centers where rural households do their shopping and where they spend nearly all their money. This is not to say that there are not any important trade linkages between the study region's service centers and larger centers located elsewhere, but these are primarily trade flows of intermediate goods that usually form the content of interregional trade. Most of the goods and services considered for this study are either locally produced or distributed or both, and the demand for them is expected to have significant income and employment multiplier effects in the larger villages and small towns that supply them to the rural households.

Historically, the positive changes that took place in North Arcot's agriculture between 1974 and 1983 are reflected in changes in the distribution of population and service provision among settlements, the spatial features of middle-order service centers, and the index of service provision. By 1983, additional viable locations were available for services because the proportion of settlements with populations between 2,500 and 9,999 persons had grown from 25 to 30 percent, and, along with the investment in agricultural technology, public and private investment in rural infrastructure had been decentralized. The provision of services was more balanced, with the former domination by large towns and cities being significantly diluted. With the emergence of eight new middle-order service centers, it is expected that each center need not cover as wide a geographic area as in the earlier period. Indeed, during the period of agricultural transformation, the mean service provision score per square kilometer rose for total service, public service, private service, and for each service category except banking, for which the geographic coverage remained static but the business volume grew. Other studies have shown that the development of rural service infrastructure benefited from income growth brought about by agricultural transformation, but these studies have also noted that the "green revolution" was itself facilitated by investment in rural infrastructure.

The principles of central place theory are applicable for explaining the development in North Arcot. The hierarchy of services and service centers is as expected in theory. High-order service centers do provide a greater variety of services to a broader area and a larger population than do low-order service centers. However, the theoretically predicted hexagonal shape for service areas is not apparent. And, in contradiction to theory, more than one of the three factors—marketing, transport, and administration—that are supposed to singularly influence spatial organization affect the service system in North Arcot. Marketing and transport principles influence the emergence and growth of low-order services and service centers, whereas all three principles are relevant for the emergence and growth of middle- and high-order services and service centers.

Coupling economic theory on consumer behavior with geographic theory on spatial organization provides even greater insight for analysis of infrastructure policy than does either alone. Central place theory is a helpful construct for applied analysis of this kind, and the present study helps to validate, correct, and expand the theory, particularly for planning the distribution systems of goods and services in developing countries.

2

INTRODUCTION

Rural Infrastructure and Agricultural Development

Although researchers' and policymakers' interest in rural infrastructure and its impact on agricultural and regional development in developing countries is growing, infrastructure is not easy to define. Generally, when the research community refers to infrastructure, they mean roads, telecommunications, electrification, and irrigation—that is, hard infrastructure. But focusing only on hard infrastructure provides only a partial picture. Other elements of infrastructure are equally important, notably institutional and "soft" infrastructure.

Local data on climate, physiography, soils, water, vegetation, and population need to be collected, stored, and analyzed by government agencies before agricultural development is planned. Normally this task is performed by national institutions in collaboration with their regional and local counterparts. The absence of this institutional infrastructure can lead to unsound agricultural development planning.

Similarly, soft infrastructure—various services such as transport (bus and truck), finance (credit and banking), input distribution (of seeds, fertilizers, pesticides, agricultural machinery, and animal husbandry inputs), and marketing (of agricultural and other rural produce)—is also necessary for the development of agriculture.

The economic and spatial features of the distribution systems for these services are strong. Since the services are available in only a few settlements but are used by a large number of settlements, economic transactions take place over a given geographical area in which these settlements are located. Depending on their distribution, these spatial features can improve or hinder access of the rural population and alter the prospects for agricultural and economic development.

Relationship between Hard and Soft Infrastructure

Previous work in India and Bangladesh by IFPRI and others has shown that investment in hard infrastructure such as roads and irrigation systems, when coupled with simultaneous investment in the type of soft infrastructure described above, facilitates intensive agricultural development, which in turn has led to overall regional development and a reduction in poverty.[1] In India, the location of soft infrastructure services was planned after studying demographic, functional, and spatial characteristics of a regional settlement system consisting of both towns and villages (Wanmali 1983a). In addition, the Indian research also shows that the private sector was influenced in its decision to provide complementary soft infrastructure services by government investment in similar services (Wanmali 1983a).

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[1] See, for example, Ahmed and Hossain (1990); Wanmali (1983a, 1983b, 1985); Andhra Pradesh, Government of (1975); and Sen et al. (1971, 1975).

Access to and Use of Services

Earlier work also indicated that the use of soft infrastructure services was influenced not only by the income of the households but also by the distance of these services from the households (Wanmali 1985). In analyzing the spatial implications of access to services, it was seen that some services, broadly categorized as agroservices, that were at a greater distance from consumers were used less frequently, which theoretically could have had an adverse effect on overall agricultural development. It was noted that making such services available at shorter distances from households could improve their use. This could also be achieved by making the services mobile, that is, moving them about to increase their availability (Wanmali 1985). The savings in both money and time in obtaining these services could be retained locally and could be used in both the producer and consumer sectors of the rural economy. This, in turn, would strengthen the service and demand linkages in that region, thus reinforcing regional economic growth and development (Wanmali 1985).

Only by understanding hard, institutional, and soft infrastructure, can the effects of infrastructural development on agricultural development in any region be adequately explained. In doing so, it is important not to equate national investments in hard infrastructure with direct economic gains at the local level and to realize that long-term economic gains cannot be achieved without simultaneous local investment in soft infrastructure. It is also important to understand the spatial implications of national investment in hard and soft infrastructures for regional development.

Rural Infrastructure and the Geographical Analysis

Geographical analysis can help in studying the distribution of infrastructure and people over space and time, particularly in analyzing access of people to infrastructure. The geographer categorizes infrastructure and people in order to understand their relationships and to address the question of access. In addition to categorizing infrastructure as hard, institutional, and soft, the geographer categorizes people as urban or rural, agriculturalist or nonagriculturalist, skilled or unskilled, rich or poor, males or females, adults or children, and literate or illiterate. Distance, which separates people from infrastructure, is categorized not only by geographical distance (in kilometers), but also by time and money spent in obtaining these services.

Towns and Villages

Infrastructure and people are mostly located in towns and villages. Accessibility can vary depending upon where a specific settlement is located in the wider settlement system. Towns, being larger, provide better access to services than villages. Locating services properly throughout a region is therefore crucial to improving access of the farming population to them. Making services available in distant towns is not of much help locally.

Settlement System

All activities in a region (such as agriculture, mining, manufacturing, trade, services, transport, finance, and governance) are part of the settlement system of that region. An analysis of the settlement system, therefore, can indicate the existing patterns of relationships between a region's population and its infrastructural services.

Services are located in settlements and these locations are a result of the capacity of the settlements to sustain them. Once established, services tend to be used not only by the settlements in which they are located but also by people from the surrounding settlements. Thus, the relationship between a center that offers a particular service or group of services and its dependent territory can provide useful information on the functional and spatial characteristics of the settlement system.[2] This relationship has a variety of implications for the patterns of use of services at both the regional and household levels.

Geographical Aspects of Development

Other properties of service use fundamentally related to distance are worth noting. In geographical studies of development, it is recognized that use of services varies directly with income and social status, and that it declines away from towns and cities. Distance to services is an indicator of ease of access to services. In any development effort, there exists a "distance decay" away from the center and toward the periphery. Analysis of the relationship between the center and the periphery, particularly involving infrastructure and people, is fast becoming a centerpiece in all current literature in geography on regional development planning in the Third World.[3]

Current economic analyses of relationships between infrastructure and people and their effects on each other often use such indicators as income or cost as a means of understanding these relationships. A geographical analysis of use of services as influenced by distance would complement this economic analysis admirably and would result in a fuller understanding of the problem. The theoretical underpinning of such a geographical analysis is central place theory, which has been found useful in conducting geographical exercises in many areas of both the developed and developing worlds (Christaller [1933] 1966).

Scope of the Study

This report presents a geographical analysis of the provision and use of hard and soft infrastructural services in rural regions of North Arcot District of Tamil Nadu, India, based on survey data collected in 1982/83. The analysis relates to the demographic, spatial, and functional features of the settlement system of the study region.

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[2] A number of studies have been conducted in various parts of the world analyzing this relationship. Some of the better-known Indian studies are Rao (1964); NCAER (1965); Wanmali (1968, 1970, 1981, 1983a, 1983b); Misra, Sundaram, and Rao (1974); Sen et al. (1971); Wanmali and Khan (1970); Alam and Khan (1972); Shah (1974); and Bhat (1976).

[3] See, for example, the 10 volumes edited and published by the United Nations Center for Regional Development (Misra 1981).

In this report, the term "settlement" means a census village, not a sociofunctional entity, as exists in the study region. The analysis identifies service center hierarchies in the study region based on the provision of both hard and soft rural infrastructural services. It also identifies "gaps" in the provision of these rural infrastructural services within the study region. An attempt is made to determine what effect hard infrastructure such as roads has on the emergence and development of soft infrastructural services, such as the distribution of credit, banking, seeds, fertilizers, pesticides, marketing of agricultural products, animal husbandry, communication, health, education, and other goods and services. A brief discussion of the socioeconomic characteristics of sample households sets the scene for analysis of the impact of access to rural infrastructural services on the expenditure patterns of the households. Special attention is paid to household expenditure on production and consumption goods and services. The geographical analyses of gaps in the provision of rural infrastructural services, the median population threshold for services, and the results of the analysis of the impact of access to rural service infrastructure on the expenditure patterns for consumption and production goods and services at the household level help provide a list of locational priorities to enable policymakers to make decisions on the geographical pattern of investment in rural infrastructural services. The implications of this analysis for initiating improvements in the distribution systems of soft infrastructural services are noted. Changes in the agricultural sector that occurred between 1974 and 1983 in the study region and in the regional pattern of provision and use of services are outlined.

Data Base

Two sets of data were collected from the study region during a field survey in 1982/83 by IFPRI and its collaborating organization, Tamil Nadu Agricultural University (TNAU), one relating to the pattern of provision and use of services at the village and town levels and the other relating to the pattern of expenditure on them at the household level. Data also included demographic and socioeconomic characteristics of households.

Regional Data

The first data set covered the availability of 134 services belonging to different groups, which included education, health, communication, banking and finance, transport, agricultural inputs, animal husbandry, marketing, and retail services in the 535 larger settlements in the six *taluks* of North Arcot. Information was also gathered on which settlements use which other settlements for what services, over what distances, and with what modes of transport. Settlements with fewer than 750 people were excluded from the study because of time and cost constraints. When analyzed, these data describe the geographical patterns of provision and use of services at the village and town levels and provide the basis for identifying gaps in the provision of rural infrastructural services.

Of the nine groups of services noted above, all except communication services are provided by both the government and the private sectors. Thus, in the study region, it is commonplace to find government and private schools and colleges, clinics and hospitals, banks and financial institutions, bus and truck transport systems, fertilizer, seed, pesticide, and agricultural machinery depots, veterinary clinics and hospitals, agricultural marketing centers, and, of course, retail services of various kinds coexisting side by side. The communications services dealing in postal and telecommunication activities, however, are solely provided by the government.

Some recall data were also collected in 1982/83 regarding the pattern of distribution and use of services in 1973/74, when a household-level survey of the region was conducted by the universities of Cambridge and Madras. The Cambridge/Madras survey did not collect data on the pattern of distribution and use of services, but the 1982/83 survey by IFPRI and TNAU made a reference to it in order to jog the memory of the respondents. Since the quality of this recall data is not very good, only broad generalizations can be made with regard to changes in the geographical distribution and use of services on the basis of its analysis.

Household Data

The second set of data, also collected in 1982/83 by IFPRI and TNAU, covered the details of services used by 345 households, sampled separately according to household type: paddy farm operator, nonpaddy farm operator, cultivation laborer, and noncultivator. The households were similar to those covered by a large longitudinal survey of 11 sample villages from the 6 *taluks* of the study region during 1982/83. This collaborative data collection exercise by IFPRI and TNAU obtained information on income and expenditure of the sample households for one year through monthly surveys.

There is, however, one important lacuna in this data base. No information was obtained on prices of goods and services in the study region. Considering that the study covers 134 different services and that there are differences in prices of goods and services based on differences in quality, it was too difficult to obtain information on prices for all the goods and services. For inputs and outputs, the prices in the study region were administered by the government, and even the private sector set its prices very close to the administered prices. What appears to govern the consumption of input and output services is the many nonprice factors identified in the study. This is not to say that prices are unimportant in the study region, but, for the reasons stated, the task of gaining price information was too formidable to undertake and accomplish.

What the data contain, however, are details of expenditures on items that make up the various groups of services in the econometric analysis undertaken in Chapter 5. These expenditure data are used in estimating the impact of access to rural service infrastructure on expenditure patterns at the household level.

Another lacuna that needs to be mentioned here is that the data do not contain any information on the time required by households to obtain a service, even when it is accessible. Although this is an important factor influencing the use of services, no information on it was collected during the 1982/83 field surveys.

Survey Design

The households were sampled for the field survey in the following way. The choice of the study region and of the sample villages in which the sample households are located was governed by the availability of earlier data from the surveys conducted by the universities of Cambridge and Madras.[4]

1973/74 Rural Survey by the Universities of Cambridge and Madras

A two-stage sampling design was used. The first stage involved the selection of a representative sample of 11 villages for the study region. The sampling frame used was the 1971 census of all villages in the study region having a population between 50 and 5,000 people, but excluding villages located in reserved forests or hilly regions.

The 11 villages were selected from a population of 989 villages using simple systematic random sampling. The list was obtained by arranging the villages in the following order: (1) by contiguous *taluks*, (2) by distance from town within a *taluk*, (3) by 1971 population size, (4) by the ratio of agricultural laborers to cultivators, and (5) by spatial proximity (as indicated by village location codes given in the 1971 census). Then every k^{th} village (where k is the inverse of the sample ratio) was selected from the list, the first selection being at random from the first k units in the list.

All the households in the selected villages were listed, and, for each household, basic information was collected on the size and composition of the family, their principal means of livelihood, and their landholdings. These data were used to select the second-stage samples.

Several different household samples were selected and questionnaires used to obtain socioeconomic data on the households. The first survey was a sample of 161 paddy farm households who participated in a detailed farm management survey for the agricultural year ending with the 1974 *sornavari* crop. (The light monsoon season, the *sornavari*, occurs in the summer months and ends in August or September.) A paddy farm was defined as a holding of one-quarter acre or larger on which paddy could be grown. Prior to selection, the paddy farms in each village were arranged according to whether they grew high-yielding varieties (HYVs) and had an irrigation pumpset or an iron plow. They were further ranked by farm size and by the maximum area planted to paddy in any one season. Once ordered in this way, systematic sampling with equal probability was used to select a sample in each village.

The second survey was a household sample of 57 paddy farms, 3 nonpaddy farms, and 77 noncultivator households who participated in a monthly income and expenditure survey between April 1973 and May 1974. The 57 paddy farm households were selected from the sample of 161 paddy farmers included in the farm management survey. The sampling procedure used was the same as described above.

The sample of 77 noncultivator households was selected by circular systematic sampling, with equal probability, after arranging the noncultivator households in each village by (1) principal means of livelihood, (2) region and caste, and (3) household size. A noncultivator household was defined as a household with less than a quarter acre of land available to them. It also includes landless agricultural laborer households.

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[4] For details of the survey conducted by the University of Cambridge (UK) and the University of Madras (India) in the early 1970s, see Farmer (1977).

The sample of three nonpaddy farm households was selected by simple systematic sampling with equal probability from the list of households in each village having only dry land. Before sampling, the households were arranged in increasing order by area of operated land, by land tenure classes, and by household size.

1982/83 Rural Survey by IFPRI and TNAU

As in the 1973/74 survey, all the households in the 11 villages were listed, and basic information was collected to form a sampling frame. The 1973/74 listing questionnaire was used, and this involved collecting information on the size and composition of the family, occupation, primary source of income, landholding, ownership of irrigation wells and lifting equipment, type and condition of house, and ownership of cycles and radios.

The listing data were used to classify the households into three groups: paddy cultivators, nonpaddy cultivators, and noncultivating households. As in 1973/74, a cultivator was defined as a farmer operating more than a quarter acre. Different sampling procedures were used to draw a sample within each group.

The paddy cultivators in each village were first sorted into six subgroups according to whether they possessed a pumpset and whether they were tenant farmers, owner-occupiers, or both. Within each group, they were then classified by operated farm size. Preliminary calculations using the 1973/74 survey data showed that a sample size of 160 should provide estimates of aggregate household expenditure that would have a 90 percent chance of falling within plus or minus 10 percent of their true values. Hence, using a predetermined sample size of 160 paddy cultivators for the 11 villages, the sample was allocated among the villages to obtain the same sampling ratio in each village. Systematic random sampling with equal probability was used.

The nonpaddy cultivators in each village were sampled by simple random sampling. Since households fell into this category in 1982/83, it was decided to select a total sample size of 25 households from the 11 villages. The sample for each village was determined so as to obtain equal sample ratios across villages.

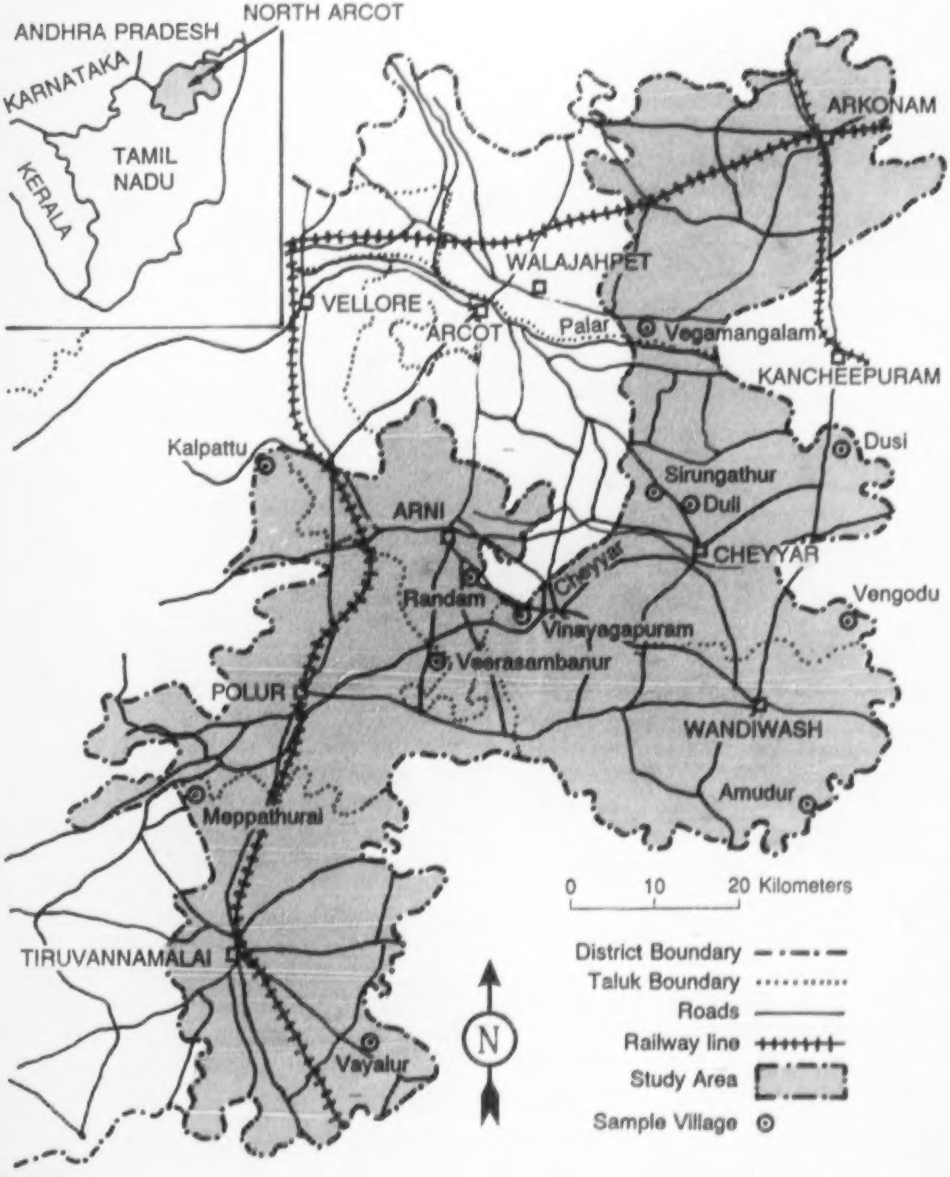
The noncultivator households were selected by systematic random sampling. A total sample size of 160 households was allocated among the villages to obtain a constant sampling ratio. Within each village, households were sorted into nine groups according to their primary source of income: agricultural labor, other casual labor, trader, village artisan, cottage or village industry, professional service, landlord or renter, money lender, and others. Within each group, the households were then arranged by family size.

All the selected rural households were administered inventory questionnaires in February 1982 and June 1983. From March 1982 to April 1983 they participated in a monthly income and expenditures survey, which also included detailed farm management and nonfarm business data where appropriate. These data are used in the analysis of household patterns of service use in the study.

The Study Region

Six eastern *taluks* of North Arcot District form the study region. The *taluks* are Arkonam, Arni, Cheyyar, Polur, Tiruvannamalai, and Wandiwash (see Figure 1). For the purposes of development administration, these *taluks* are further divided into the

Figure 1—The study region


NORTH ARCOT
ANDHRA PRADESH
KARNATAKA
TAMIL NADU
KERALA
ARKONAM
WALAJAHPET
VELLORE
ARCOT
Palar
Vegamangalam
KANCHEEPURAM
Dusi
Kalpattu
Sirungathur
Duli
ARNI
CHEYYAR
Cheyyar
Vengodu
Randam
Vinayagapuram
Veerasambanur
POLUR
WANDIWASH
Amudur
Meppathurai
0
10
20 Kilometers
TIRUVANNAMALAI
N
Vayalur
District Boundary
Taluk Boundary
Roads
Railway line
Study Area
Sample Village

following 17 community development blocks: in Arkonam Taluk, Arkonam, Kaveripakkam, and Nemili; in Arni, Arni and West Arni; in Cheyyar, Cheyyar, Anakavur, and Vembakkam; in Polur, Polur, Kalasapakkam, and Chetpet; in Tiruvannamalai, Tiruvannamalai, Thurinjapuram, and Kilpennathur; and in Wandiwash, Wandiwash and Thellar.

The study region has an area of 5,508 square kilometers, and it lies between 11°55′ and 13°15′ north latitude and 78°50′ and 79°50′ east longitude. The general slope of the region is from west to east. The western part of the study region is partly bordered by the Javadi Hills, which are a part of the Eastern Ghats. According to the *Census of India* (1981), the population of the study region is about 1.6 million, giving it a population density of 290 persons per square kilometer. There are 1.1 million workers in the study region. Sixty-eight percent of the region's work force is engaged in agriculture or agriculture-related activities. Of the total population of the district, only 23 percent are in urban centers.

Agriculture is the predominant activity in the study region, and paddy, groundnuts, ragi, pulses, and sugarcane are the most important crops. Milk production is also important. A thriving agroprocessing industry is an important part of the manufacturing sector. Other prominent manufacturing activities are tanneries and silk and cotton textile mills.

In the chapter that follows an attempt is made to introduce the theoretical frame of reference of the study. This relates to the theory of location of services in a settlement system of a region and the impact of these locations on economic development in the region.

3

THEORETICAL FRAMEWORK: CENTRAL PLACE THEORY

The theoretical frame of reference of this study is based on the central place theory formulated by Walter Christaller ([1933] 1966) and modified by others (Haggett 1965).[5] In this chapter six basic concepts of central place theory are defined with a view to understanding how they may be applied, and further developments in theory are noted.

Definitions of Basic Concepts

Centralization as an Ordering Principle

The centralization of mass around a nucleus is an elementary form of organization. This centralistic order exists in all patterns of matter, whether inorganic or organic. Christaller believes that services tend to concentrate around points that are more important rather than around those that are less important.

The Central Place

The most important aspect of Christaller's idea of the central place system is the central place itself. The basic unit is a settlement: it could be a city or a town or a village. The distinguishing characteristic of a central place is that it provides goods and services to an area larger than itself. The services may be extensive or limited, but the *service function* is common to all central places.

The central place is the center of a region, but the term *central* is relative. Settlements that are mainly centers of a region are called central settlements; those that are not central are known as dispersed places.

According to central place theory, places that have central functions and that cater to the population of a larger region in which central places of lesser importance also exist are central places of higher order. Those that are only important in their immediate vicinity are called, correspondingly, central places of lower order. Small places usually not having central importance are called central places of auxiliary nature.

Importance and Centrality

Every place has a degree of importance, which usually is defined rather inexactly by its size of population or by its areal size. Neither population or area precisely expresses the meaning of the word "importance" or centrality. The theory says that the importance of a settlement is not the sum of the number of its inhabitants, but rather the sum of their combined economic efforts.

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[5] In addition to Christaller (1966), see Berry and Garrison (1958); Berry and Pred (1961); Berry (1967), particularly chapter 4; Beavon (1977); and Berry and Parr (1988).

The Central Functions

Central functions are those which, by their nature, are available in a few places but are availed of by a number of places. In fact, the degree of importance of a function varies inversely with the frequency of its occurrence. Central place theory, therefore, classifies central functions as *higher-* and *lower-order* functions. The lower-order functions belong to a lower-order central place or an auxiliary central place. Christaller believes that all consumer-oriented functions belong to the central place. In fact, he suggests that the processing of raw materials could be done at a central place. Industries like food processing, dairies, sugar refineries, and fruit preservation plants could very well be located in central places of higher order. The central functions considered by Christaller are trade, banking, administration, education, commerce, and transportation.

Complementary Regions

Intraregional complementarity includes both the relation of the place to its region and vice versa. The complementary region of a central place is difficult to delineate because, in essence, it involves the demarcation of the variable ranges of the many functions performed by a central place. Where a central place has a surplus of importance, a complementary region has a deficit: one counterbalances the other.

Economic Distance and the Range of a Good

In classical central place theory, geographical supply of and demand for goods and services are determined by freight, insurance, and storage costs; delivery time; loss of the good; and by the ease of movement, travel cost, and travel time. Two notions are used to describe the geographical movement of goods and services. One represents the maximum distance over which the demand for a good is positive, called the *range* of a good or the upper limit. The other represents the minimum distance wherein exists the minimum volume of demand for the good to ensure normal profits to the seller. This is the *threshold* or the lower limit.

It can be shown that each good or function has its own characteristic range, which is likely to vary from one central place to another and to change over time. The range of central functions offered at central places of higher order is larger than the range of lower-order places. When the range is expressed spatially as a radius, it forms a circle or a ring around the central place. The range has an upper and a lower limit. The former is a *spatial* index determined by the farthest distance from the central place where a good or function can be obtained; the latter is a *quantity* index determined by the minimum number of people required to support that function in the central place.

The Process of Emergence and Growth of a Central Place

What effects do distribution of population, the size of the region, and the range of central functions have on the emergence and growth of central places?

Demand for Central Functions

The consumption of (demand for) central functions depends upon the distribution of population and the pattern of transportation—an important factor affecting the development of a central place. The higher the population of a region, the greater is the consumption of a central function; this will result in a higher-order central place offering these functions and vice versa.

Supply of Central Functions

Dispersed distribution of population, particularly on scattered farms, is not conducive to satisfactory access to central functions of even the lowest order. For example, where the population is dispersed, even grocers, bakers, and butchers are significantly absent. Such a situation will result in comparatively better development of higher-order central places because all services will be located there, but there will be very few places of lower order. In a region where villages predominate, however, the higher-order central place is deprived of its central functions to some extent because some of the large villages perform lower-order central functions. Therefore, central places of both higher and lower order will be found in such a region. Thus the development of central places in regions of dispersed farms is generally poorer than that in regions with many villages.

Interaction of Demand for and Supply of Central Functions

Although demand for central functions is very important in the development of central places, demand is itself dependent upon other factors. First, where incomes are limited, demand is restricted because consumers do not have money to spend. Second, demand is restricted where the existing supply—volume or amount—of functions is limited.

An example of a central function with a given quantity and a set price is a hospital with a fixed number of beds. If the beds are filled in hospital A, the people whose demand could not be met there will have to go to hospital B, which may be located in a neighboring area. However, they then have to consider the cost of transportation. Therefore, the most favorable location for a central place is the one where the total existing amount of the function is just equal to the total demand.

Other Factors Influencing the Distribution of Central Functions

The size of the area, the landscape, the means of transportation, natural conditions, fertility of the soil, availability of minerals, and whether the whole or a part of the region belongs to a central place characterize the complementary regions. In thinly populated regions, the consumption of functions per unit of area is less than that in thickly populated regions. Hence, low population density and large areal size in a region lead to the development of a central place system with an inferior pattern. Conversely, high population density and small areal size may lead to a superior pattern.

The importance of transportation in the development of central places should not be underestimated. Transport represents an economic relationship between consumers and central places, and as a result of the preference consumers show for central places, transport forms a network of interconnected settlements around places of higher order. This network tends to cover places of lesser order also. Therefore, a good transport system tends to strengthen central places. However, in an area where the transportation network is poor, central places will be poorly developed.

The quality of functions also affects the growth of central places, but this factor appears to come into play at a stage when the economy is well developed. In an earlier stage, when physical availability itself is the crucial aspect, the quality of a function is relatively unimportant in the emergence and development of a central place.

Central Place Models

In its most comprehensive formulation, the central place theory would provide a complete framework for the study of the formal and functional attributes of settlements and regions, the types and patterns of linkages between them, and their dynamics. But neither Christaller's model ([1933] 1966) nor that of Loesch (1954)—the two most elaborate models of the central place concept—are comprehensive enough to fulfil this role. However, because these two models form the basis of the central place theory, an examination of their salient features is in order. The two models are described here in broad terms, touching only on their main arguments, both explicit and implicit. Finally, recent developments in the theory are examined in the light of the two classical models.

General Description

The two central place models explain the horizontal (spatial) and vertical (functional) distribution of settlements in a region and their interrelationships (hierarchies). The locale of activity is assumed to be an unbounded, homogeneous plain (isotropic surface), where uniform distribution of population, resources, producers, consumers, and so forth is the rule; movement in every direction is unimpeded; and unit costs are equal.

Christaller's model is developed by describing, first, how market areas (the complementary regions described earlier) for different goods emerge. Market areas are bounded areas, determined by the cost of transportation (the range of a good discussed earlier). The quantity demanded of a good decreases spatially with every increase in the distance between the sites of supply and demand because of the rise in the cost of transportation. At a particular demand site, the price plus the transport cost of a good may become prohibitive, and the quantity demanded drops to zero. Since ease of movement and the unit cost of transportation in any direction around the central settlement (site of supply) are assumed to be uniform, the distance between the site of supply and the point where quantity demanded is zero will be the same in each direction. Therefore, the market area will be circular in shape. But, as will be seen presently, this has to be regarded as a first approximation of the shape of the bounded area. What needs be stressed here, however, is that the market area indicated by the range of a good should also generate the minimum demand (threshold) to allow normal profits to sellers. This would be the minimum size market. Further, it can be demonstrated that in a competitive situation the market available to each individual seller of a good will always be of the minimum size.

Circular market areas are not ideal in a competitive situation for reasons that can be easily demonstrated. There are two possible ways for circular market areas to fit into a given space. First, a number of unserved areas could arise between three or more circular market areas; second, two or more market areas could overlap considerably. In the first case, instability is inherent because new firms could locate in the unserved populated areas, thereby encroaching seriously on the market areas of the neighboring sites. The ultimate solution would be to split the unserved areas equally between the neighboring market areas. Where market areas overlap, it is evident that the overlapping zones will tend to be distributed between the competing sites. Thus, hexagonal market areas of the minimum size would emerge for each good.

This general description is valid for both Christaller's and Loesch's constructions.

Differences Between Christaller and Loesch

As far as the *horizontal* arrangement of settlements is concerned, Christaller's solution yields uniform spacing of equal-order settlements; higher-order central places are more widely spaced than lower-order ones. In Loesch's model, concentration of settlements occurs in sectors separated from each other by sectors of low settlement density. Further, settlement size (in terms of geographical area) increases with distance from the central settlement and, consequently, small-sized settlements are sandwiched midway between two larger settlements.

Equally, if not more, important are the differences in *vertical* (functional) organization between the two models. The fixed-K assumption of Christaller yields a rigid hierarchy in which higher-order central places provide *all* lower-order goods (provided by the lower-order central places) *plus* one or more higher-order goods.

Similarly, for every higher-order central place in Christaller's model, there is a fixed number of lower-order central places, but this number varies according to the three principles of spatial organization that Christaller recognizes. These are the marketing principle, where for every higher-order central place, there are two lower-order central places; the transport principle, where the number of lower-order central places is three; and the administrative principle, where the number of lower-order central places is six. These numbers are known as k-values in the theory.[6]

The variable-K assumption of Loesch, which recognizes functional specialization of places, implies, first, that *all* central places of the *same order* need not contain the same functions; and second, that higher-order central places need not have all the functions performed by the lower-order central places. Vertical organization in the Loeschian model is more continuous than in Christaller's construction, with its discrete distribution of central places. Thus, in Loesch's model, it would not be impossible for points derived from several principles of spatial organization to converge at the same place. This is not the case with Christallerian construction, where only one principle is seen to influence the emergence of central places.

Departures from the Hexagonal Form

Isard (1956) has pointed out that Loesch retains the hexagon although it is not consistent with some of the implications of his solution. Loesch postulates uniform distribution of the consuming population (see isotropic surface, p. 27), but his model indicates varying degrees of concentration of activities and functions (agglomerations) at different central places. Implicitly, the density of population is higher around the highest-order central place and declines progressively as one moves outward from that point. Thus, areally, the minimum-size market areas (see threshold and range of a good) nearer the core should be smaller and those at increasing distances from it should be larger. As a result of this distortion, market areas would assume rectilinear or rhomboidal shapes.

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[6] In discussion of central place hierarchy, the capital letter K indicates the span of control of higher-order centers. Thus, according to the marketing principle, k represents the three next lower-order complementary regions.

Besides agglomerations, any resource localization pattern that differs substantially from the uniform distribution of resources (isotropic surface) assumed by the classical models is bound to distort the hexagonal geometry. Three such hypothetical distribution patterns can be visualized. In the first case, resources are assumed to occur only at one point (for example, a coal field with all active pits concentrated in a relatively small space). Three patterns of settlement locations and market areas would result. In the first, settlements would cluster around a node, all sharing with the node the market areas at whose apexes they are located. In the second, resources are assumed to occur in a wide zone, but not uniformly over the entire unbounded space. Central places of the resource-poor areas will locate as close to the resource-rich zone as possible and not necessarily in the exact center of their respective market areas. In the third, resources are assumed to occur linearly. Central places will be located along the resource line with their market areas diagonal to it on either side (provided the resource line does not hinder movement across it) or on the side on which the central place is located (Haggett 1965).

Nonhexagonal Central Place Models

The hexagon, the means of formalizing central place hierarchy in the classical models, is a pure concept. But the central place concept is not a pure or formal idea in that sense. Even if all the assumptions on which the constructions of Christaller and Loesch are based were relaxed, the concept of central place functional hierarchy would be unaffected. There are two well-known variants of the central place model, not based on the classical formal assumptions, that provide satisfactory exposition of functional hierarchies. Both are empirically derived and are amenable to geometrical interpretations.

The first of these is the regular cluster model associated with Kolb and Brunner (1946). It has a remote skeletal prototype in the observations of Galpin regarding the evolution of movement-networks in agricultural communities (Berry 1967). The regular cluster model, which in essence is an alternative hypothesis to the regular model, specifies neither directions nor distance. Its basic assumption, which conforms to the real situation, is spatial interaction between settlements on the principles of a positive relationship between their size and pull (attraction) and an inverse relationship between their distance and pull. Thus, the following patterns characterize spatial interaction: the largest settlement (town) is centrally located; the next smaller settlements in size (villages) find locations on the periphery of the zone of pull of the town; and the next smaller settlements (hamlets) ring around the villages. Smaller settlements are likely to develop close to each other rather than close to the larger ones. The functional hierarchy implied in the model is one of direct dependence of smaller settlements on larger, and of the latter on the largest settlement of the system.

The other case referred to earlier in this connection is a study of the functional hierarchy of settlements in southwest Iowa, in which Berry (1967) deals with and defines a system of central places, without the aid of geometrical forms, using only maps, flow charts, and—only incidentally—rudimentary geometry. The findings of this study can also be interpreted in the terminology of the classical models. In a more recent statement, Berry and Parr (1988) observes characteristics of central place systems in areas of formal and informal trade and exchange in rural, suburban, urban, and metropolitan economies.

A "Mobile" Central Place Model

Finally, mention should be made of the model of periodic central places proposed by Stine (1962), which is of interest because of its operational potential in areas with low population densities or poor communications or both.

Stine observes that if the range of a good (the upper limit) and its threshold (the lower limit) are expressed as circles with radii of appropriate lengths, then the circle representing the maximum range of a good will contain the circle representing the threshold. However, in a physical setup that restricts free movement of consumers, the relationship between the two circles may become inverted. In a situation like this, since the minimum necessary demand conditions are not fulfilled, the firm supplying the good—if it sets up business at all—will soon disappear, being unable to sustain recurring losses. However, the firm may still make normal profits and offer services, provided it gives up its fixed location and becomes mobile. If the firm becomes mobile, the number of trips it may have to make and the distance over which it may have to travel in order to find the minimum necessary demand will depend on the difference between the radii of the circles describing the range of the good it deals in and its threshold. The itinerant vendors operating periodic markets in the countryside, particularly in the Third World, are an example. This model suggests the use of mobile units for the provision of specific rural infrastructural facilities.

Relevance of Central Place Theory to the Current Analysis

In any exercise analyzing the availability and use of rural service infrastructure, the central place theory can serve as the basic framework. It is true that the theory was originally formulated to explain the locations and functions of and relationships between urban areas (cities and towns). But this need not detract from its application to nonurban areas. With certain modifications, the main construction, with all its essential features, can be employed for such areas. In brief, the central place theory has three main elements: urban centers, their hexagonal market areas, and transport networks. By replacing rural settlements for urban centers, service areas for hexagonal market areas, and movement patterns for transport networks, the theory can be made applicable to a nonurban hierarchy.

The relevance of this theoretical framework has been tested extensively in South Asia, but less often in other parts of the Third World.[7] Although approaches to these studies have tended to be varied even in the South Asian context, their findings have unmistakably pointed toward the applicability of central place concepts in the urban and rural areas of the countries of South Asia. An attempt is made in the subsequent chapters of this report to analyze the settlement system of North Arcot District within the theoretical framework noted in this chapter and to demonstrate what aspects of the theory are applicable to the settlement system of the study region. An attempt is also made to investigate what influence household expenditure patterns can have on the emergence and growth of central places in South Asia. Given that Christaller only referred to this influence but never pursued it in his deductive theory, it would be a useful extension of the theory to identify inductively how central places emerge and grow as a consequence of household expenditure patterns. Since this is one of the few studies, if not the only study, that looks at both the regional provision of and household use of central functions in a Third World region, the study helps to extend the application, and understanding, of central place concepts in the Third World more fully than ever.

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[7] See, for example, Wanmali (1970, 1981, 1987); Sen et al. (1971); Misra, Sundaram, and Rao (1974); and Alam and Khan (1972).

4

REGIONAL PROVISION AND USE OF SERVICES

The state of Tamil Nadu has paid increasing attention to rural development schemes since the early 1960s.[8] These schemes have had a strong impact on agricultural, industrial, and infrastructural development in North Arcot District. As will be seen in this report, provision of services in the villages and towns of the study region, as a result of policies to expand public utilities and other governmental, quasi-governmental, and private-sector schemes, has greatly influenced the patterns of service use at both regional and household levels.

Services such as bus and truck transport, credit, banking and marketing of animal husbandry inputs, seeds, fertilizers, pesticides, agricultural machinery, agricultural produce, and rural products form the core of soft infrastructural services. Some other services can also be added to this list, including education and health services, as well as the entire gamut of retail services. In this analysis, these are all considered to be soft infrastructural services. They can also be defined as central functions, as noted in the previous chapter.

In this part of the analysis, details of service provision and use at the settlement level are given, with particular reference to the identification of service centers and their spatial characteristics and the incidence of service provision. As mentioned earlier, these spatial characteristics relate to areas and populations served by service centers and to functional hierarchies, which in their turn are helpful in identifying and delineating the progressively complex specializations in the pattern of provision and use of services in a settlement system. This analysis helps in identifying gaps in the provision of services in the study region. It also helps in understanding the regional context within which the sample households are located. Access to these services and their effects on the expenditure patterns of the sample households will be analyzed in the next chapter.

Services and Their Distribution

The total service provision in the study region can be divided into nine major groups: (1) education, (2) health, (3) communications, (4) banking and finance, (5) transport, (6) cultivation inputs, (7) animal husbandry, (8) marketing, and (9) retail services.

The list of individual services in each group in Table 1 was compiled after visiting each of the 535 settlements selected for this study. Table 1 also indicates the number of settlements in the study region that have that particular service. It depicts

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[8] For lack of space, this report does not include all of the details of administrative history, physical and economic features, adoption of new agricultural technology and modern inputs, and broad patterns of development in recent years for the study region.

Table 1—Service groups and ranking of services

Service	Number of Villages with Service
Education services	
Primary school	522
Middle school	272
High school	96
Higher secondary school	28
College	3
Health services	
Allopathic clinic	246
Family planning camp (mobile)	22
Family planning clinic	30
Primary health center	27
Private hospital	33
Government hospital	26
Pathological and radiological tests	8
Communication services	
Postage	457
Money order	387
Registration	384
Postal order	66
Telegram	44
Radio license	131
Telephone	149
Banking services	
Primary cooperative credit society	135
Land development bank	10
Agriculture cooperative bank	18
Commercial bank	17
Nationalized bank	15
Lead bank	22
Transport services	
Passenger bus service	354
Transport of goods by road	17
Passenger train service	16
Transport of goods by train	15
Agricultural input and implements services	
Purchase of	
Tools	368
Implements	49
Electric motors	4
Electric pump sets	5
Oil engines	4
Sugarcane crushers	3
Sprayers	4
Dusters	4
Threshers	1
Seeds	63
Fertilizer and pesticides	82
Rental of	
Tools	443
Implements	448
Oil engines	299
Sugarcane crushers	103
Sprayers	352
Dusters-	282
Threshers	100
Tractors	153
Cage wheel	122
Servicing of	
Tools	466
Implements	422
Electric motors	90
Electric pump sets	81
Oil engines	57
Sugarcane crushers	18
Sprayers	95
Dusters	83
Threshers	6
Tractors	3
Cage wheel	3
Animal husbandry services	
Key village centers	116
Veterinary dispensaries	42
Marketing services	
Sale of	
Vegetables	100
Fruits and coconuts	52
Paddy	34
Bajra	155
Jowar	163
Pulses	98
Castor	85
Groundnuts	34
Other oilseeds	91
Sugarcane	22
Jaggery	27
Chilies	110
Turmeric	11
Tamarind	34
Poultry products	425
Dairy products	519
Firewood	89
Retail services	
Blacksmith	494
Carpenter	492
Cobbler	495
Retail petty shop	524
Retail cloth shop	58
Tea and coffee shop	483
Laundry	497
Barber	510
Bakery	395
General provisions	382
Ready-made garments	33
Household utensils	17
Medical shops	15
Glassware	5
Pottery	457
Electrical goods	32
Footwear	17
Bicycle sales	6
Bicycle repair	410
Timber	15
Fuel	404
Bricks/tile	406

(continued)

Table 1—Continued

Service	Number of Villages with Service	Service	Number of Villages with Service
Cement	32	Jewelry	11
Stone	348	Furnishings (bed mattresses)	23
Lime	35	Arrack[a] shops	463
Hardware	17	Foreign liquor	10
Wooden furniture	273	Bookbinding	17
Steel furniture	8	Printing	17
Opticals	2	Sweet shops	27
Stationery	76	Leather goods	11
Watch sales	6	Photography	16
Watch repair	23	Purchase of vegetables	281
Radio sales	4	Purchase of fruits	347
Radio repair	24	Purchase of poultry products	485
Transistor sales	4	Purchase of meat products	405
Transistor repair	21	Purchase of dairy products	501
Scooter repair	7	Cold drinks	503
Automobile repair	7	Restaurant	291
Petrol, diesel fuel, and lubricants	8		

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

[a] Arrack is an Asian alcoholic beverage distilled from a fermented mash of malted rice, coconut palm juice, and date palm juice.

a pattern of distribution of services in which the more rudimentary services exist in a large number of settlements and the more complex exist in only a few of them.

Hierarchy of Services

In the present pattern of distribution of villages and towns in the study region, there appears to be a lack of settlements of certain population sizes.[9] These "breaks" in the regional settlement system were observed at different population sizes and are the basis for dividing the total service provision structure into three groups. This categorization reflects the complexity of services available in settlements: (1) low-order services, which are defined as those first occurring in settlements with populations smaller than 1,000; (2) middle-order services, which first occur in settlements with populations between 1,000 and 3,500; and (3) high-order services, which first occur in settlements with populations larger than 3,500. Some settlements in the last group are towns. There are 48 services in the low-order category, 75 in the middle-order, and 11 in the high-order (Table 2).

Entry Thresholds of Services

Entry thresholds of services, in this part of the analysis, are defined by the population size at which a service first occurs within the study region. These thresh-

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[9] This feature is not unique to this settlement system. Such gaps in settlements of a certain size exist in all settlement systems; however, their exact location varies from one region to another. See, for example, Sen et al. (1971) and Wanmali and Khan (1970). Further, over time, the location of such gaps may shift, in terms of population size, within a settlement system (Wanmali 1983a, 1983b).

Table 2—Hierarchy of services according to size of settlement where they first appear

Low Order (48)	Middle Order (75)	High Order (11)
Primary school Middle school Allopathic clinic Postage Money order Registration Postal order Telegram Radio license Telephone Primary cooperative credit society Commercial bank Bus stop Tools (purchase) Tools (rental) Implements (rental) Oil engines (rental) Sprayers (rental) Tractors (rental) Tools (service) Implements (service) Sprayers (service) Key village center (veterinary subcenter and dairy collection center) Marketing of poultry products Marketing of dairy products Blacksmith Carpenter Cobbler Petty shop Tea and coffee shop Laundry Barber Bakery General provisions Pottery Bicycle repair Fuel Bricks/tile Stone Lime Arrack (local liquor) shop Vegetables (purchase) Fruits (purchase) Poultry products (purchase) Meat products (purchase) Dairy products (purchase) Cold drinks Restaurant	High school Higher secondary school Family planning camp Family planning clinic Primary health center Private hospital Government hospital Land development bank Agriculture cooperative bank Nationalized bank Lead bank Railway station Rail shipment Road shipment Implements (purchase) Electric motor (purchase) Electric pumpsets (purchase) Oil engine (purchase) Sugarcane crusher (purchase) Sprayer (purchase) Duster (purchase) Thresher (purchase) Sugarcane crusher (rental) Duster (rental) Thresher (rental) Cage wheel (rental) Electric motor (service) Electric pumpset (service) Oil engine (service) Sugarcane crusher (service) Duster (service) Thresher (service) Tractor (service) Cage wheel (service) Seed (purchase) Fertilizer and pesticide (purchase) Veterinary dispensary Vegetable market Fruit and coconut market Paddy market Bajra market Jowar market Pulse market Castor market Groundnut market Other oilseed market Sugarcane market Jaggery market Chili market Turmeric market Tamarind market Firewood market Retail cloth shop Ready-made garment Household utensil Medical shop Glassware Electrical goods Footwear Timber Cement Hardware Wooden furniture Steel furniture Stationery Watch repair Transistor radio repair Jewelry repair Furnishing Foreign liquor Bookbinding Printing Sweet shop Photography	College Pathological and radiological testing Bicycle sales Opticals Watch sales Transistor sales Radio sales Scooter repair Automobile repair Petrol, diesel fuel, and lubricants Leather goods

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

olds are noted for all services. It should not come as a surprise that the more rudimentary and, therefore, more commonly available services have low entry threshold values (Table 3).

Ranking of Services and Centrality of Settlements

Although there are nine groups of services in the study region as a whole, not all settlements have all services, nor are services available in all settlements at the same level of complexity. That is, not all of the components of a service group are necessarily available in each settlement. The services, therefore, can be arranged on the basis of their entry thresholds in order to arrive at their ranking.[10] Depending upon its threshold value, each of the services has a "weight" assigned to it to help arrive at a score for a settlement's total service provision, which is referred to as the centrality of a settlement (Table 3). For example, if the entry threshold value of a primary school is a population of 806, its weight would be 1.00; for a middle school where the entry population threshold is 918, the weight would be 1.14.

The centrality of a settlement is a measure of its importance, which is defined here as a function of all the services provided by it. By considering the variety, hierarchy, and number of services available in a settlement and multiplying the number by the appropriate weight, it is possible to arrive at an indicator of the settlement's centrality. Thus, continuing with the same example, if a settlement has two primary schools and one middle school, its centrality score for education services will be $(2 \times 1.00) + (1 \times 1.14) = 3.14$. Centrality was calculated for all 535 settlements.

Broad Patterns of Service Provision

It is possible to argue that higher levels of concentration of population in settlements would result in better provision of services and conversely that these services would be physically more accessible to greater concentrations of population. When centrality scores and distances of services were plotted against the population size of settlements in this study, it was not surprising to see that, as population size increases, the distance to services generally declines and the level of service provision (centrality) improves appreciably for all services (Figures 2 and 3).

These patterns of physical access to services are of particular interest. Some services are easily accessible in terms of distance to all settlements; others are uniformly inaccessible. Still others are inaccessible to all settlements with populations below 2,000 (there are 360 settlements in this category and all are villages), but are easily accessible to settlements with populations of more than 5,000 (many of the 23 settlements in this category are towns).

The centrality patterns are exactly the opposite of the physical accessibility patterns. For example, as the population size increases, the centrality scores increase. Thus, the association between higher centrality scores and larger population size is unmistakable.

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[10] For a detailed discussion of methods of ranking see Wanmali (1971, 1983a, 1983b).

Table 3—Thresholds and weights of services

Service	Threshold of Service	Weight of Service
	(minimum population)	(population/108)
Education services		
Primary school	806	1.00
Middle school	918	1.14
High school	1,021	1.27
Higher secondary school	1,334	1.66
College	19,274	23.91
Health services		
Allopathic clinic	806	1.00
Government hospital	1,075	1.33
Family planning clinic	1,084	1.34
Primary health center	1,084	1.34
Family planning camp	1,480	1.84
Private hospital	1,505	1.87
Pathological and radiological tests	5,583	6.93
Communication services		
Postage	860	1.07
Money order	860	1.07
Registration	860	1.07
Radio license	860	1.07
Telephone	860	1.07
Postal order	918	1.14
Telegrams	918	1.14
Banking services		
Commercial bank	860	1.07
Primary cooperative credit society	918	1.14
Lead bank	1,075	1.33
Agriculture cooperative bank	1,440	1.79
Nationalized bank	1,440	1.87
Land development bank	1,508	1.87
Transport services		
Passenger bus stop	806	1.00
Passenger train stop	1,327	1.65
Transport of goods by train	1,327	1.65
Transport of goods by road	1,961	2.43
Agricultural input and implements services		
Tools, purchase	806	1.00
Tools, rental	806	1.00
Sprayers, rental	806	1.00
Implements, rental	806	1.00
Oil engines, rental	806	1.00
Tools, servicing	806	1.00
Implements, servicing	806	1.00
Tractor, rental	806	1.07
Sprayer, servicing	918	1.14
Sugarcane crusher, rental	1,002	1.24
Dusters, rental	1,002	1.24
Electric motor, servicing	1,012	1.26
Oil engine, servicing	1,012	1.26
Dusters, servicing	1,012	1.26
Seed	1,012	1.26
Fertilizer/pesticides	1,012	1.26
Cage wheel, rental	1,015	1.26
Thresher, rental	1,023	1.27
Implements, purchase	1,072	1.33
Sugarcane crushers, servicing	1,254	1.56
Threshers, servicing	1,380	1.71

(continued)

Table 3—Continued

Service	Threshold of Service	Weight of Service
	(minimum population)	(population/108)
Tractors, servicing	1,380	1.71
Cage wheel, servicing	1,380	1.71
Electric pump sets, purchase	1,829	2.27
Oil engine, purchase	1,829	2.27
Sugarcane crushers, purchase	1,829	2.27
Sprayers, purchase	1,829	2.27
Dusters, purchase	1,829	2.27
Threshers, purchase	1,829	2.27
Electric motor, purchase	2,443	3.03
Animal husbandry services		
Key village centers	806	1.00
Veterinary dispensaries	1,035	1.28
Marketing services		
Sale of		
Poultry products	806	1.00
Dairy products	806	1.00
Other oilseeds	1,002	1.24
Vegetables	1,012	1.26
Fruits and coconuts	1,012	1.26
Chilies	1,012	1.26
Pulses	1,015	1.26
Tamarind	1,021	1.27
Firewood	1,021	1.27
Jowar	1,028	1.28
Bajra	1,030	1.28
Castor	1,042	1.29
Jaggery	1,042	1.30
Sugarcane	1,050	1.30
Paddy	1,119	1.39
Turmeric	1,119	1.39
Groundnuts	1,133	1.41
Retail services		
Blacksmith	806	1.00
Carpenter	806	1.00
Cobbler	806	1.00
Petty shop	806	1.00
Tea and coffee	806	1.00
Laundry	806	1.00
Barber	806	1.00
Bakery	806	1.00
Bicycle repair	806	1.00
Bricks/tile	806	1.00
Stone	806	1.00
Arrack shops	806	1.00
Purchase of vegetables	806	1.00
Purchase of fruit	806	1.00
Purchase of poultry products	806	1.00
Purchase of meat products	806	1.00
Purchase of dairy products	806	1.00
Cold drink	806	1.00
General provisions	806	1.07
Pottery	806	1.07
Lime	806	1.07
Restaurant	806	1.07
Fuel	918	1.14
Stationery	1,012	1.26

(continued)

Table 3—Continued

Service	Threshold of Service	Weight of Service
	(minimum population)	(population/108)
Cement	1,014	1.26
Wooden furniture	1,015	1.26
Retail cloth shop	1,031	1.28
Hardware	1,036	1.29
Ready-made garments	1,075	1.33
Watch repair	1,075	1.33
Radio repair	1,075	1.33
Transistor repair	1,075	1.33
Sweet shop	1,075	1.33
Foreign liquor	1,075	1.33
Timber	1,164	1.44
Furnishings (bed mattresses)	1,270	1.58
Electrical goods	1,352	1.68
Household utensils	1,395	1.73
Photography	1,924	2.39
Footwear	1,924	2.39
Jewelry	2,443	3.03
Medical shops	2,456	3.05
Steel furniture	2,540	3.15
Bookbinding	2,540	3.15
Printing	2,540	3.15
Glassware	3,426	4.25
Leather goods	5,026	6.24
Petrol, diesel fuel, and lubricants	5,583	6.93
Scooter repair	7,889	9.79
Automobile repair	7,889	9.79
Radio sales	16,083	19.95
Transistor sales	16,083	19.95
Bicycle sales	16,083	19.95
Watch sales	16,083	19.95
Opticals	38,664	47.97

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

The distribution of service provision in the study area is such that numerous settlements with low scores—below 70—dominate the rural scene; there are only a few settlements with very high scores—up to 4,000 (Table 4 and Figure 4). These gaps in service provision exist, as will be seen later, because service provision for large rural areas in the study region is poorly planned, which adversely influences the use of rural services.[11]

Travel Patterns and Categorization of Settlements

Since the availability of services is not uniform across the study region, nor are all services needed and used located in a settlement, people must travel in order to

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[11] This pattern of distribution of service provision is also not unique to the study area. It has been found to exist in other parts of India, although the location of the gaps according to the centrality scores will vary from one region to another. See Sen et al. (1971) and Wanmali (1970, 1983a, 1983b).

Figure 2—Relationship between population size and average distance to services by service category

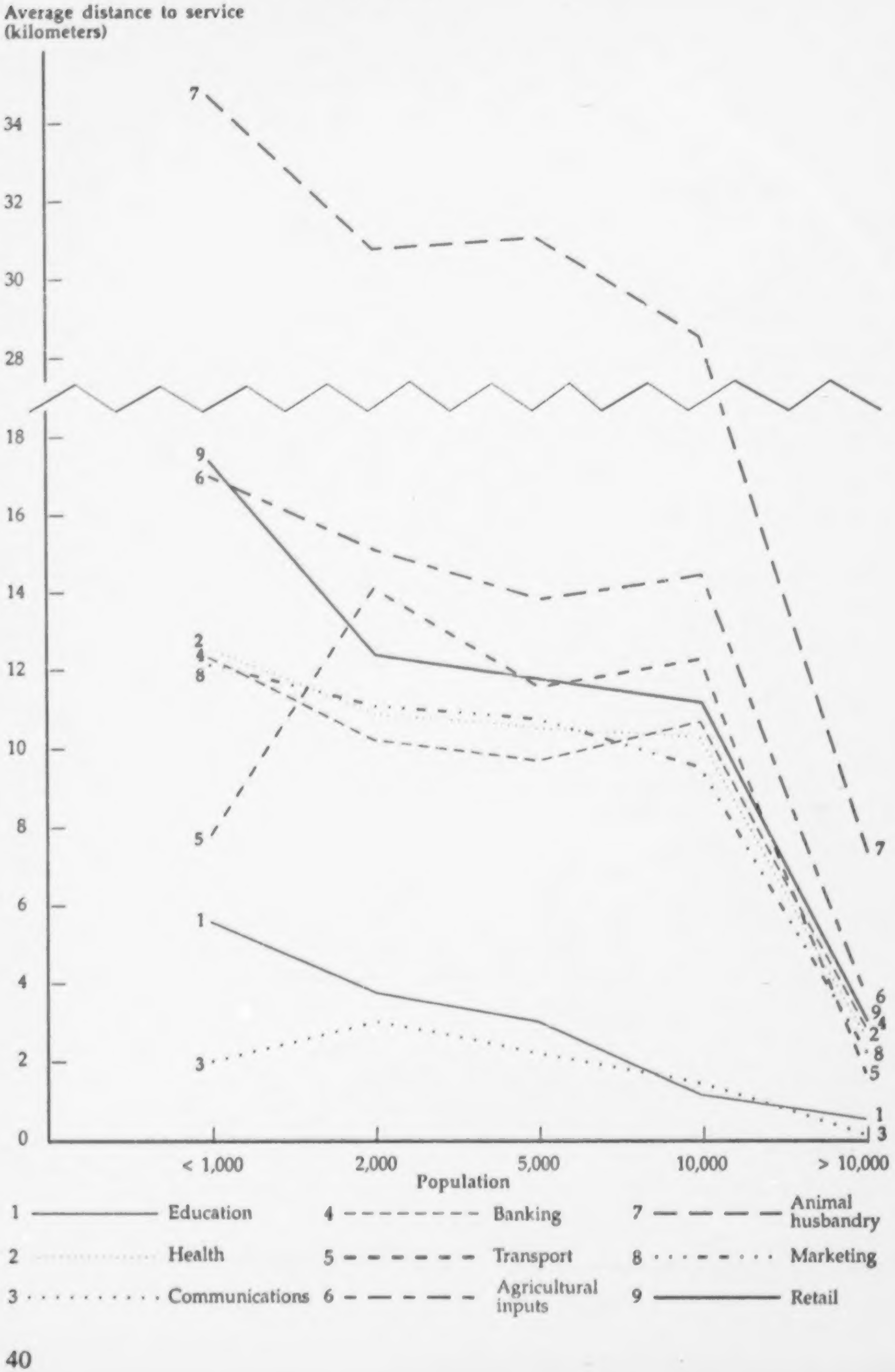

Figure 3—Relationship between population size and average centrality of services by service category

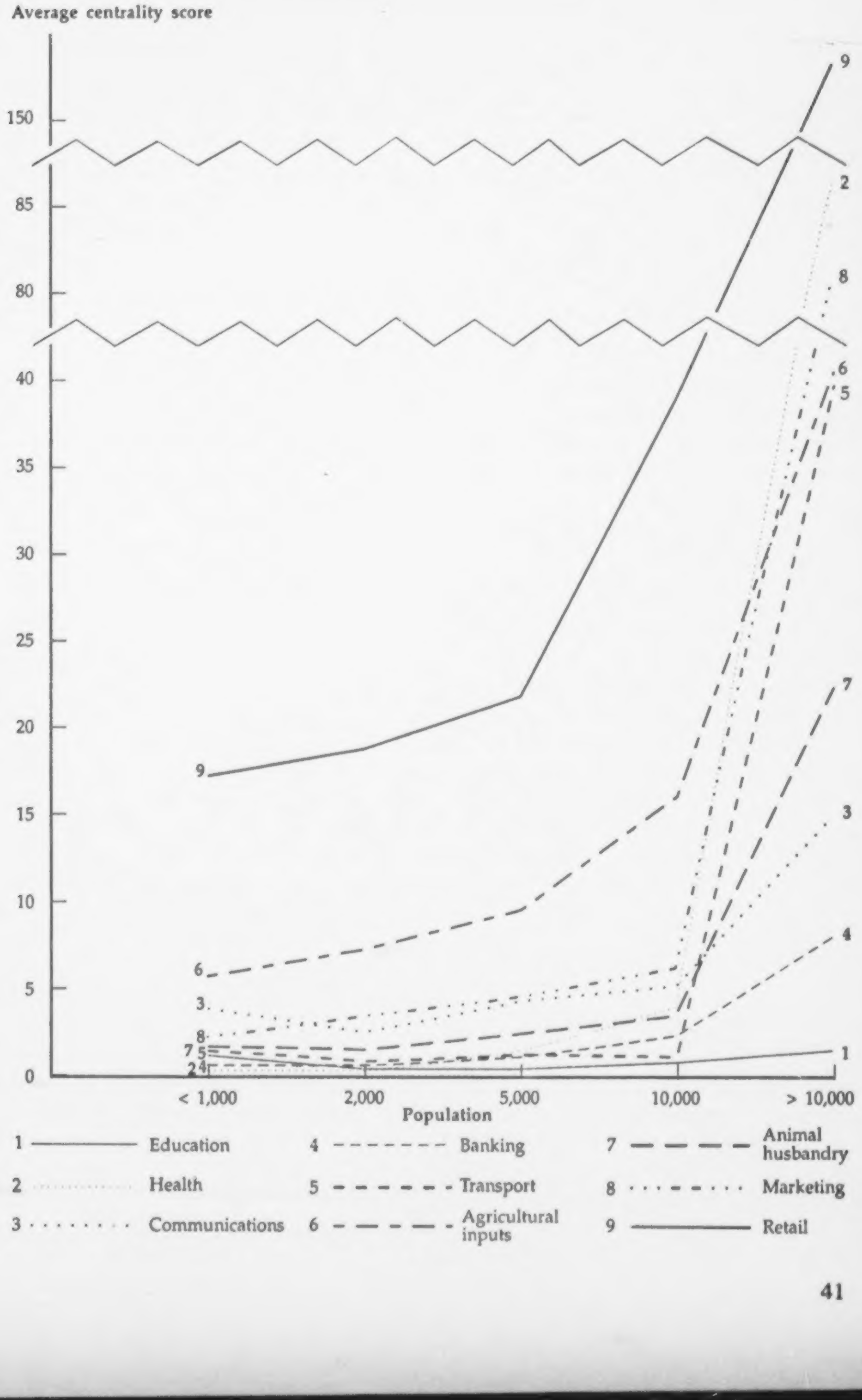

Table 4—Centrality scores for service provision and distribution of settlements

Score	Number of Settlements	Sum of Scores	Percent of Total
10.00 - 40.00	334	10,686.95	46.52
40.01 - 70.00	169	7,976.84	34.69
70.01 - 100.00	15	1,230.24	5.35
100.01 - 130.00	9	1,085.68	4.73
130.01 - 3,999.99	8	2,000.80	8.71
Total	535	22,980.51	100.00

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

avail themselves of services located outside of their own settlements. Which settlements have what types of services and what is the pattern of regional travel to them?

All settlements in the study region were visited in order to obtain information about the availability and use of services. These data provided the basis for identifying the patterns of travel to each service by people from each settlement. These individual settlement-based patterns are grouped in order to understand the generalized pattern of both service provision and use.

Settlements are categorized as service centers or dependent settlements in the following way: if any settlement has more than 50 percent of services at any level of service hierarchy and if it serves any other settlement, then that settlement is termed a service center for that level of the service hierarchy. On the other hand, if a settlement depends upon any other settlement for more than 50 percent of services at any level of the service hierarchy, then that settlement is considered to be dependent on the other settlement at that level.[12] The same method can be applied separately to the provision of services at the three different levels of hierarchy.

At least two different kinds of analysis can be undertaken on the basis of the survey data: one relates to the identification of service centers, their dependent settlements, service population, service areas, and the number of settlements served; the other concerns the service population and service area for each of the services. In both these analyses it can be expected that higher-order service centers and services will serve larger areas and populations than lower-order service centers and services.

The Hierarchy of Service Centers

Low-Order Service Centers

There are 12 settlements in the study region that qualify as service centers at the low level of service provision, having more than 50 percent of the services considered and serving at least one additional settlement. However, there are 461 other settlements that have more than 50 percent of the services considered but serve only

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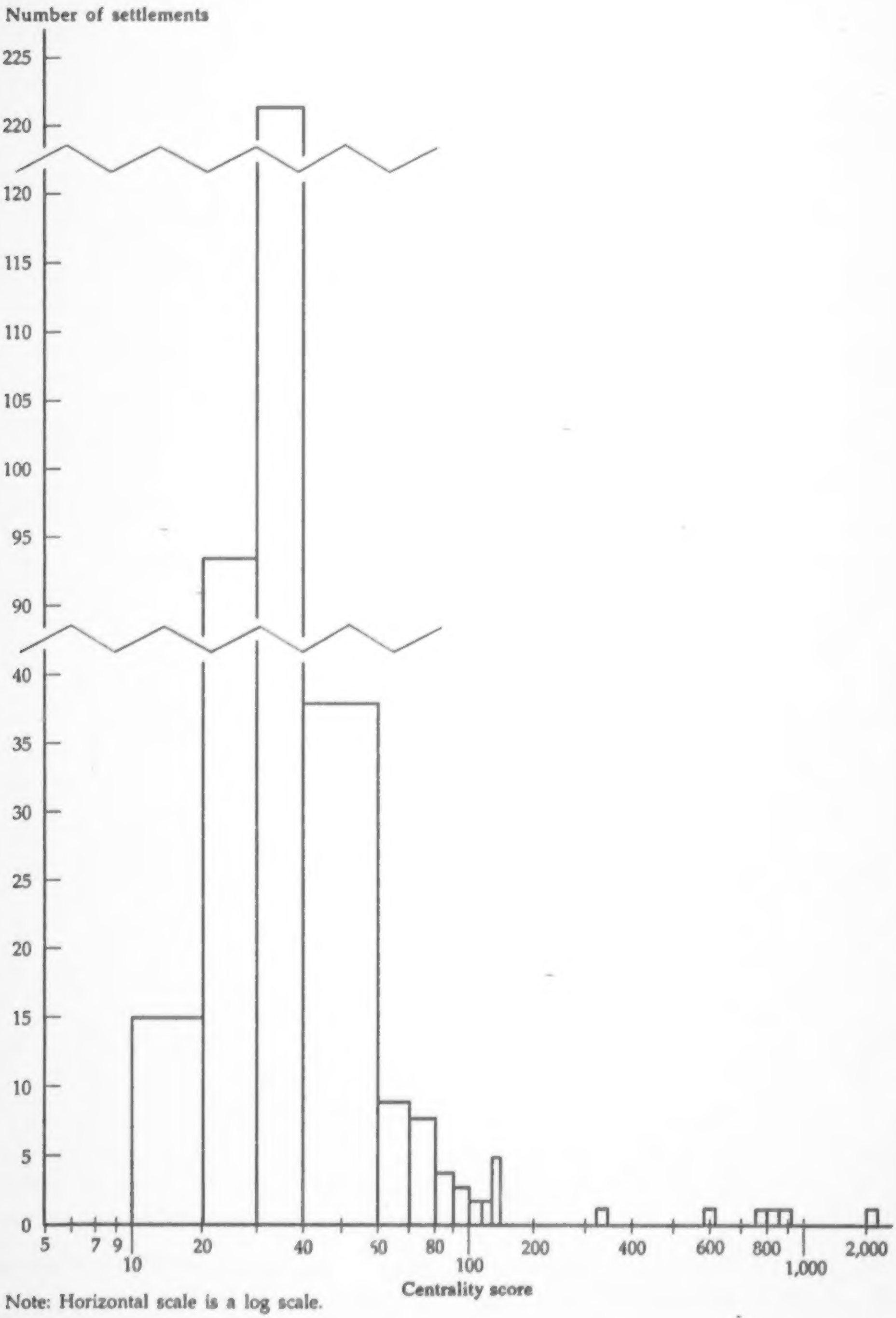
[12] Sen et al. (1971) uses the same type of categorization.

Figure 4—Histogram of centrality scores



Note: Horizontal scale is a log scale.

themselves. These settlements are called "relatively self-sufficient" in the sense that, at this level of service provision, they do not depend upon any other settlement to satisfy their demand for services. Given that the services provided are rudimentary, it is not surprising that so many qualify as relatively self-sufficient. Combined they serve 493 settlements out of 535 in the study region. On average, each low-order service center serves 1.04 settlements including itself; together they serve almost a million people and cover almost 3,075 square kilometers.

Middle-Order Service Centers

There are 22 middle-order service centers serving the study region. Five of these, however, are located outside of the region. Of the 17 within the region, 10 are small service centers, servicing a total of 21 settlements (an average of 2.1 settlements per service center). The other 7 are quite large, serving altogether 311 settlements (an average of 44.4 settlements per service center). Among the outside service centers, Kancheepuram in Chengalpet District is significant because it serves 21 settlements from the study region (Table 5). It is interesting to note that, for the middle-order services, the influence of Vellore (which is acknowledged locally to be the most important service center in the district) is nonexistent. This is because Vellore is outside the study region, and because other service centers of this order of hierarchy within the region provide middle-order services to the settlements of the study region.

Of the 17 service centers within the study region, 6 are *taluk* headquarters (Arkonam, Arni, Polur, Thiruvathipuram (Cheyyar), Tiruvannamalai, and Wandiwash); 8 are block headquarters (Chetpet, Desur, Kalasapakkam, Kaveripakkam, Kilpennathur, Nemili, Peranamallur, Thellar); and 3 have no revenue or developmental administrative functions (Kannamangalam, Panapakkam, and Vettavalam). The 6 *taluk* headquarters have functioned as such since at least the turn of the century, while the block headquarters were created in the early 1950s. The older centers—the *taluk* headquarters—have more services, larger service areas, greater service populations, and higher service scores than the younger centers—the block headquarters and other centers (Table 5 and Figure 5). This finding not only substantiates the theory but adds an element of "time" to the explanation of the range of services offered by service centers. At this level of service provision, the influence of the service centers within the study region on service provision is significant. Service centers within the study region serve 89.71 percent of the middle-order service area (out of 2,198 square kilometers), 90.72 percent of middle-order service-using settlements (out of 366), and 92.20 percent of the middle-order service population (out of 876,365 people).

High-Order Service Centers

There are 12 high-order service centers in the study region, serving a total of 391 settlements, 975,051 people, and 2,470 square kilometers of area. Seven service centers—Arkonam, Arni, Chetpet, Polur, Thiruvathipuram (Cheyyar), Tiruvannamalai, and Wandiwash—are within the study region and serve 64 percent of the high-order service-using settlements, 67.4 percent of the high-order service population, and 62.5 percent of the high-order service area. Of these, Arkonam, Arni, Tiruvannamalai, and Wandiwash are the most important because they serve a large number of settlements. Of the outside service centers, two—Kancheepuram and Vellore—are significant. Six of the seven service centers from within the study region are *taluk* headquarters and thus are important administrative centers for revenue and

Table 5—Spatial features of the study region for middle-order service centers

Center and Subregion	Total Score[a]	Service Population	Service Area (square kilometers)	Number of Services	Settlements Served[b]
Centers and subregions inside the study region					
Chetpet	919.47	35,226	87.37	92	17
Desur	110.70	4,301	6.59	90	1
Kalasapakkam	109.99	2,443	2.08	85	1
Kannamangalam	129.44	5,026	9.98	94	1
Kilpennathur	166.70	10,471	24.60	96	2
Nemili	170.67	6,498	14.77	96	3
Peranamallur	126.74	4,256	14.97	96	1
Thellar	122.43	6,513	14.70	74	2
Arkonam	3,314.67	108,085	201.87	117	33
Arni	5,160.26	154,661	420.18	116	59
Polur	1,228.76	32,318	57.55	102	11
Thiruvathipuram (Cheyyar)	1,281.55	35,821	61.78	103	14
Tiruvannamalai	8,245.30	267,490	650.83	109	108
Wandiwash	2,081.55	71,656	212.86	103	35
Kaveripakkam	709.27	14,141	32.68	99	5
Panapakkam	149.10	8,748	9.94	88	2
Vettavalam	196.50	12,121	23.46	92	3
Centers and subregions outside the study region[c]					
Kancheepuram	887.71	40,599	140.78	n.a.	21
Solingar	262.76	12,846	42.73	n.a.	7
Tirukovilur	40.93	1,482	2.89	n.a.	1
Tirutani	159.77	12,376	34.32	n.a.	4
Uthramerur	39.63	1,061	6.25	n.a.	1

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: A subregion is the area surrounding a service center and served by it; it takes its name from the town that is the service center. n.a. is not available.

[a] The total score is derived from the weighted population size at which a service first appears in a village.

[b] This is the number of villages dependent on the service center for at least 50 percent of services.

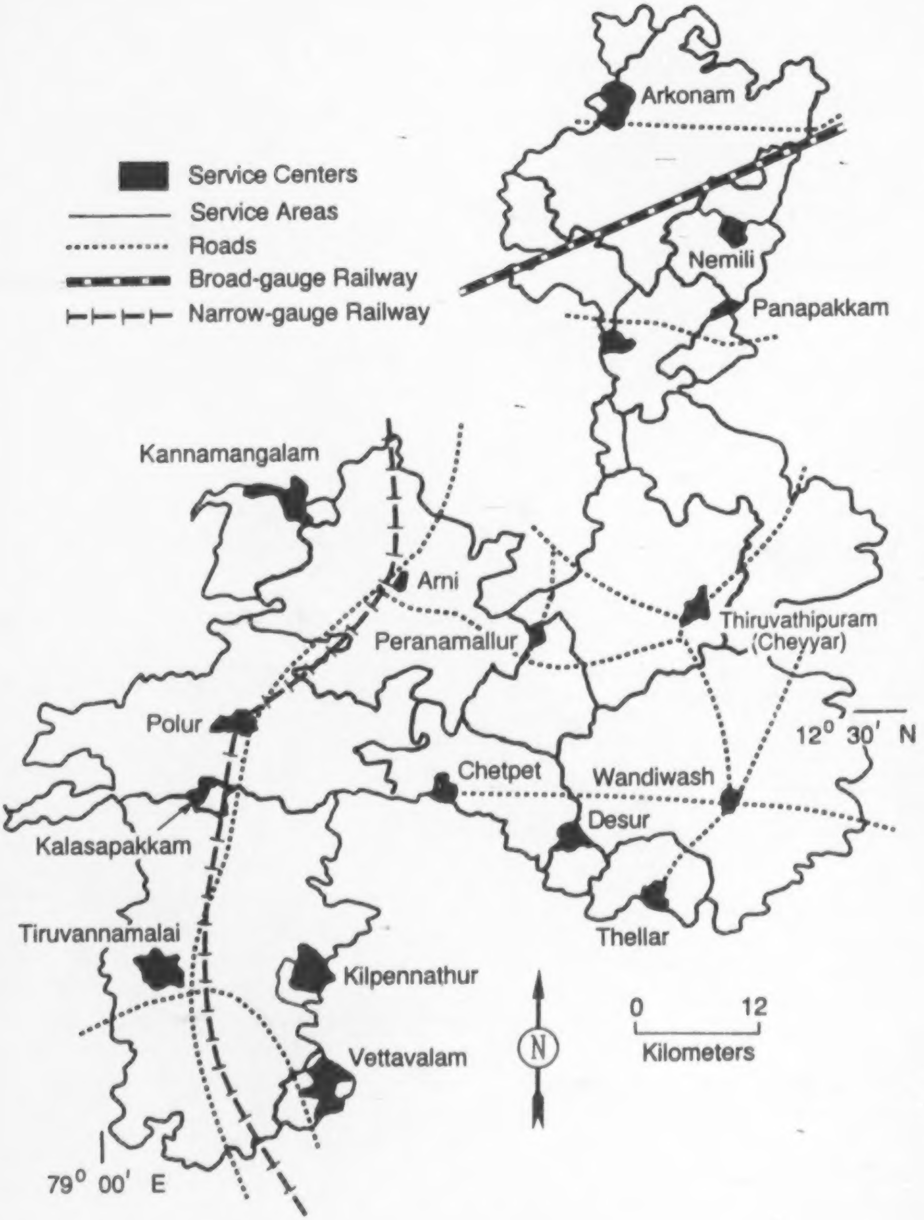
[c] Information about service centers outside the study region is incomplete.

development, and the seventh is a block headquarters. When the data are carefully analyzed, it becomes clear that settlements that have some form of administrative or development function are also the more important service centers at the higher levels of functional hierarchy (Table 6 and Figure 6). There is a greater dependence on outside service centers at this level of service provision than at any other level. The emergence and growth of these service centers with development and administrative functions and the middle- and high-order services are the consequence of several principles of spatial organization operating in the study region.

Functional Characteristics of Service Centers

At each level of service provision, the most important service center (the one with the highest total score) has the greatest number of services, the highest service

Figure 5—Middle-order service centers


Arkonam
Service Centers
Service Areas
Roads
Broad-gauge Railway
Narrow-gauge Railway
Nemili
Panapakkam
Kannamangalam
Arni
Peranamallur
Thiruvathipuram
(Cheyyar)
Polur
12° 30′ N
Chetpet
Wandiwash
Desur
Kalasapakkam
Thellar
Tiruvannamalai
Kilpennathur
0
12
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Vettavalam
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79° 00′ E

Table 6—Spatial features of the study region for high-order service centers

Center and Subregion	Total Score[a]	Service Population	Service Area (square kilometers)	Number of Services	Settlements Served[b]
Centers and subregions inside the study region					
Chetpet	457.56	9,375	15.96	92	4
Arkonam	3,384.25	111,398	222.11	117	34
Arni	4,664.82	129,879	325.11	116	44
Polur	1,228.76	32,318	57.55	102	11
Thiruvathipuram (Cheyyar)	1,281.55	35,821	61.78	103	14
Tiruvannamalai	8,245.30	267,490	650.83	109	108
Wandiwash	2,081.55	71,656	212.86	103	35
Centers and subregions outside the study region[c]					
Kancheepuram	2,322.89	101,753	328.50	n.a.	53
Madras	1,030.49	54,728	138.36	n.a.	21
Thindivanam	41.57	1,257	2.93	n.a.	1
Tirutani	202.93	13,672	36.88	n.a.	5
Vellore	2,328.29	145,701	417.92	n.a.	61

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: A subregion is the area surrounding a service center and served by it; it takes its name from the town that is the service center. n.a. is not available.

[a] The total score is derived from the weighted population size at which a service first appears in a village.

[b] The number of villages dependent on the service center for at-least 50 percent of services.

[c] Information about the service centers outside the study region is incomplete.

population, the most extensive service area, and the largest number of settlements served. It can therefore be said that other less important service centers "nest" under the influence of the most important service center.[13]

Further, even individual service centers display this nesting pattern. For example, Tiruvannamalai is a service center at all three levels of service provision. Its service region for the low-order services is the smallest and that for the high order is the largest. As a high-order service center, therefore, Tiruvannamalai has nested areas of successively less complex services. This exemplifies the characteristics of vertical organization of central places of different orders, noted in the previous chapter.

At the low order of service provision, every settlement is almost self-sufficient and, therefore, there is very little specialization in the provision of services. With greater complexity in service provision, there are specializations that result in spatial interaction. The low- and middle-level service centers combined, for example, provide 123 (of the 134) services; thus, the patterns of interaction for these two levels of service hierarchy provide the most complete picture of regional service use. As will be seen later, the service centers from outside the study region have only a marginal impact on service provision and that for only a handful of services.

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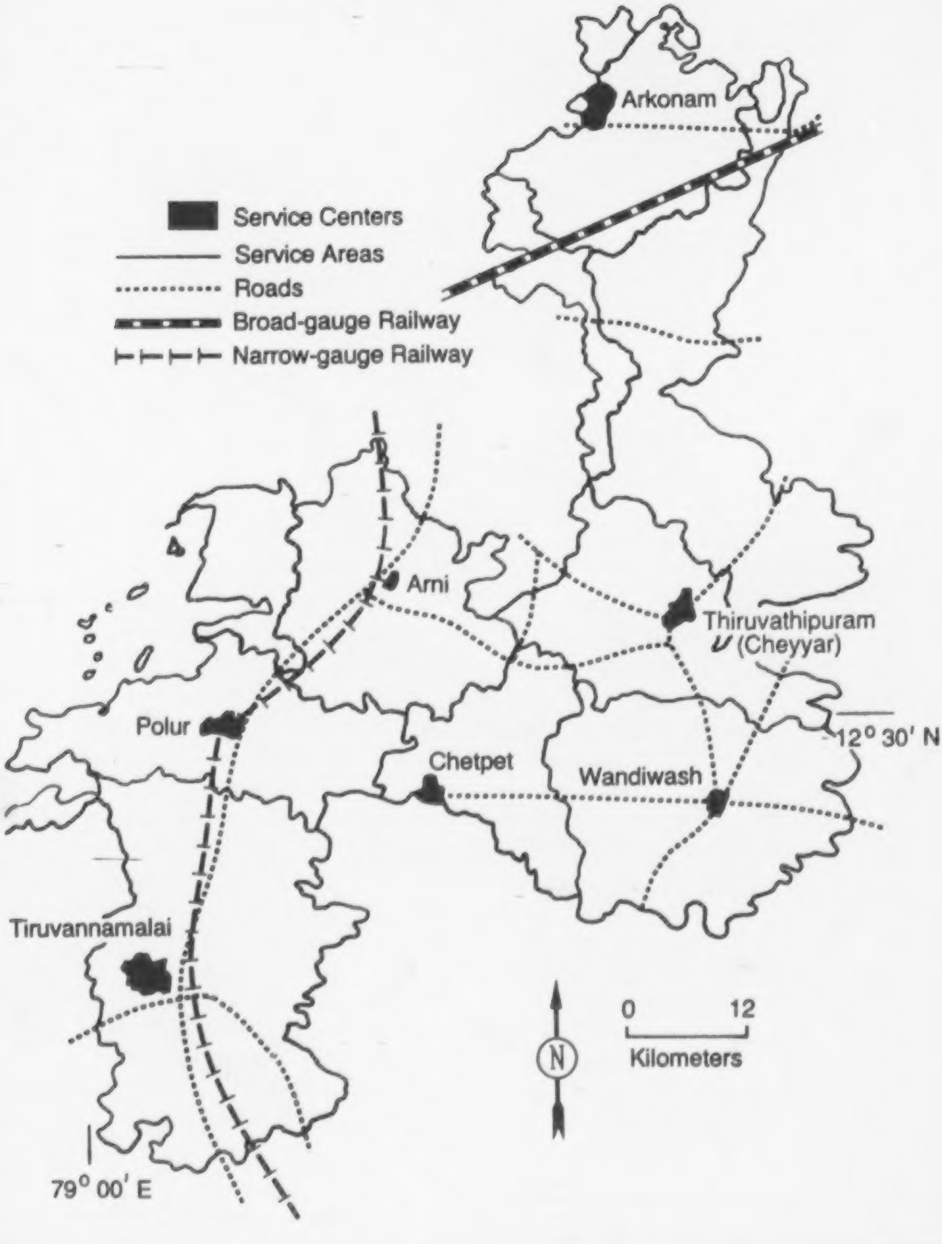
[13] Most of the studies on settlement systems throughout the world, including India, have validated this observation. See Wanmali (1970, 1983a, 1983b), Wanmali and Khan (1970), Alam and Khan (1972), Sen et al. (1971), and Bhat (1976).

Figure 6—High-order service centers


Service Centers
Service Areas
Roads
Broad-gauge Railway
Narrow-gauge Railway
Arkonam
Arni
Thiruvathipuram
(Cheyyar)
Polur
Chetpet
Wandiwash
12° 30′ N
Tiruvannamalai
79° 00′ E
0
12
Kilometers
N

All of the spatial characteristics of service centers conform with the principles of central place theory, with two exceptions: the shape of the service area of a service center and the factors that govern the number of lower-order service centers for each higher-order service center. In theory, the shape of the service area is hexagonal, but in reality, none of the service areas is hexagonal. Theoretically, the factors that govern the emergence and growth of lower-order service centers are administrative, marketing, and transport. In theory, under the administrative factor, there are six lower-order centers for every higher-order center; under the marketing factor, there are two; and under the transport factor, three. But the reality is more complex than the theory. Analysis of the data indicates that no one particular factor governs the emergence and growth of lower-order service centers in the study region. There is enough historical evidence to show, however, that a combination of all three factors has been responsible at all levels of the settlement hierarchy. There is a preponderance of marketing and transport factors governing the emergence and growth of low-order service centers, whereas all three factors govern the middle- and high-order service centers.

Two other observations are required to explain Tables 5 and 6. Data on services available in service centers outside the study region were not collected by the survey. However, data were available on travel patterns from settlements in the study region to these outside service centers. Hence, population, service areas, and service scores were derived from that data. Second, of the 535 settlements, the survey shows only a few interacting with outside service centers, perhaps because the cut-off point for service interaction was set at 50 percent. It is possible that the settlements not included in the tables belonged to categories where they depended on outside service centers for less than 50 percent of the services considered, or they depended on more than one center.

It becomes clear from the analysis of the travel patterns that the study region's dependence on service centers outside of the region increases as one moves to the high-order services. The study region is largely self-sufficient in low- and middle-order services, which together account for 123 of the 134 services used. However, many settlements use service centers located outside the study region for high-order services. Interestingly, the district headquarters town, Vellore, is used for only 11 high-order services, and then only by 61 of the 535 settlements in the study region. As was noted earlier, this is partly because of the peculiarity of Vellore's location, which makes it accessible only to settlements in the northern part of the study region.

Spatial Characteristics of Services

What is true with regard to the nesting patterns of service centers is even more true of the services themselves. For each type of service, the service area and service population tend to increase with the order of service complexity (Table 7) (Wanmali 1983a, 1983b). This neat vertical organization of services becomes somewhat confused when viewed in terms of their provision by service centers, because, at the service-center level, one is concerned with the patterns of use of all services provided by that center, not just one. This observation also conforms to the theory that lower-order services are subsumed under higher-order services.

Table 7—Average areas and populations served by services

Service	Service Area	Service Population
	(square kilometers)	(persons)
Education services		
Primary school	6.03	1,969
Middle school	10.40	3,386
High school	24.25	7,894
Higher secondary school	61.14	19,923
College	194.78	63,594
Health services		
Allopathic clinic	11.07	3,594
Private hospital	54.00	17,599
Family planning clinic	60.05	19,320
Primary health center	60.06	19,018
Family planning camp	60.77	19,627
Government hospital	74.14	24,296
Pathological and radiological tests	142.56	46,402
Communication services		
Postage	6.81	2,215
Money order	7.76	2,536
Registration	7.84	2,554
Telephone	16.83	5,442
Radio license	19.04	6,211
Postal order	33.01	10,767
Telegram	42.87	13,981
Banking services		
Primary cooperative credit society	18.64	6,083
Lead bank	63.94	20,792
Nationalized bank	65.37	21,281
Commercial bank	79.80	25,917
Agriculture cooperative bank	120.14	39,185
Land development bank	285.29	93,104
Transport service		
Passenger bus service	8.57	2,784
Passenger train service	72.97	23,789
Transport of goods by train	77.70	25,309
Transport of goods by road	86.52	28,092
Agricultural input services		
Fertilizers and pesticides	30.80	10,038
Seeds	40.18	13,051
Animal husbandry services		
Key village centers	8.66	2,788
Veterinary dispensaries	44.23	14,360
Marketing services		
Sale of		
Turmeric	4.92	3,369
Dairy products	5.98	1,967
Poultry products	6.13	2,039
Castor	7.38	2,612
Jowar	10.23	3,483
Bajra	11.02	3,735
Pulses	11.89	4,036
Other oil seeds	12.68	4,153
Firewood	15.58	5,041
Chilies	16.34	5,316
Tamarind	17.53	6,013
Fruits and coconuts	22.43	7,516
Vegetables	22.83	7,546
Jaggery	26.78	8,943

(continued)

Table 7—Continued

Service	Service Area	Service Population
	(square kilometers)	(persons)
Groundnuts	58.85	19,481
Paddy	62.52	20,575
Sugarcane	92.58	30,881
Agricultural inputs and implements services		
Tools, service	6.55	2,134
Tools, rental	6.85	2,236
Implements, rental	6.89	2,246
Implements, service	7.23	2,349
Tools, purchase	8.33	2,720
Sprayers, rental	8.41	2,737
Oil engines, rental	9.76	3,166
Dusters, rental	10.04	3,304
Tractors, rental	16.46	5,406
Cage wheel, rental	19.67	6,459
Sugarcane crushers, rental	20.94	6,906
Threshers, rental	21.62	7,104
Sprayers, service	26.50	8,626
Electric motors, service	28.94	9,414
Electric pump sets, service	29.03	9,464
Dusters, service	29.07	9,460
Oil engines, service	38.67	12,590
Implements, purchase	43.68	14,217
Sugarcane crushers, service	71.82	23,423
Threshers, service	111.54	36,415
Sprayers, purchase	120.47	39,156
Dusters, purchase	130.86	42,586
Tractors, service	134.47	43,975
Cage wheel, service	136.58	44,516
Threshers, purchase	156.19	50,946
Electric pump sets, purchase	156.89	51,112
Electric motors, purchase	163.86	53,373
Sugarcane crushers, purchase	180.23	58,967
Oil engines, purchase	184.89	60,174
Retail services		
Petty shop	6.07	1,976
Barber	6.14	2,006
Cold drinks	6.18	2,010
Purchase of dairy products	6.21	2,027
Blacksmith	6.28	2,049
Carpenter	6.29	2,050
Laundry	6.29	2,051
Cobbler	6.33	2,061
Purchase of poultry products	6.45	2,099
Tea and coffee	6.46	2,105
Arrack shops	6.60	2,154
Pottery	6.61	2,155
Bicycle repair	7.38	2,403
Bricks/tile	7.50	2,433
Purchase of meat products	7.54	2,455
Fuel	7.56	2,469
Bakery	7.67	2,503
General provisions	7.96	2,592
Purchase of fruits	8.58	2,792
Stone	8.77	2,860
Restaurants	10.13	3,290
Purchase of vegetables	10.39	3,386

(continued)

Table 7—Continued

Service	Service Area	Service Population
	(square kilometers)	(persons)
Wooden furniture	10.90	3,547
Stationery	29.83	9,725
Retail cloth shop	36.95	12,025
Lime	50.12	16,305
Electrical goods	59.84	19,542
Cement	60.95	19,772
Sweet shops	61.52	20,030
Ready-made garments	65.10	21,116
Transistor repair	69.65	22,698
Watch repair	69.97	22,778
Radio repair	70.08	22,811
Furnishings (bed mattresses)	76.59	24,932
Household utensils	77.95	25,449
Hardware	91.74	29,977
Bookbinding	98.29	31,901
Printing	98.30	32,005
Photography	98.43	32,042
Medical shops	101.09	32,950
Footwear	101.38	33,003
Timber	112.28	36,538
Leather goods	115.87	37,632
Glassware	123.32	40,489
Steel furniture	125.32	40,734
Scooter repair	143.32	46,603
Foreign liquor	148.28	48,350
Bicycle sales	155.49	50,830
Automobile repair	156.47	50,945
Jewelry	163.79	53,235
Petrol, diesel fuel, and lubricants	165.27	53,650
Watch sales	195.85	63,760
Transistor sales	196.13	63,871
Radio sales	196.76	64,087
Opticals	209.54	68,163

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Pattern of Incidence of Services

In Tables 5 and 6, where the spatial features of service centers are noted, the names of the centers listed are also the names of the subregions. Thus, Chetpet subregion has a total centrality score of 919.47, a service population of 35,226, a service area of 87.37 square kilometers, and a total number of 92 services (out of a possible 134); all these are available to residents of Chetpet town and to the 17 settlements that it serves besides itself. Thus, the subregion takes the name of the service center on which it depends for its services. The incidence of services is calculated by dividing the score values of service provision by the area for the subregions and for the study region as a whole and then obtaining the ratios of the two values. For example, if a subregion has an area of 50 square kilometers and a total service provision score of 50, and if the study region has an area of 1,000 square kilometers and a total service provision score of 2,000, then the service provision score per square kilometer would be 1.00 for the subregion and 2.00 for the study region. The ratio for the subregion would be 0.50. In this study, wherever the value of the ratio is more than 1.00, then service provision is considered above average for that subregion in that service.

Because the number of service centers is exceedingly large (473), the ratios of low-order service centers are not given in a table. However, the ratios for the other two levels of service provision appear in Tables 8, 9, 10, and 11.

In identifying the regional patterns more specifically, it is possible to note which subregions have below-average provision of which services. This exercise, however, can only be undertaken with some degree of certainty for those subregions that are fully in the study region, which should be kept in mind in examining the tables.

Middle-Order Service Provision

Kalasapakkam is the only subregion with uniformly high ratios in individual and total services. Overall, service provision in Arkonam, Arni, Desur, Kannamangalam, Kaveripakkam, Panapakkam, and Tiruvannamalai, is above average, but there are some gaps in their service provision since the values of ratios for some services are less than 1.00. Wandiwash has consistently low ratios in all services. On the whole, provision of services is below average in Chetpet, Kilpennathur, Nemili, Peranamallur, Polur, Thellar, Thiruvathipuram (Cheyyar), and Vettavalam but provision of some services is above average, as indicated by some ratios higher than 1.00 (Table 9).

High-Order Service Provision

Service provision in the subregions of Chetpet, Thiruvathipuram (Cheyyar), and Tiruvannamalai is uniformly above average in individual and total services. Arkonam, Arni, and Polur have above average values for total services, but provision of some of the individual services is below average. Wandiwash, on the other hand, has below average values for total services but some individual services are above average (Table 11).

Implications of Ratio Values

The ratio values for total service provision and for individual services in subregions primarily indicate the levels of rural service infrastructural development within these subregions. For example, Table 9 indicates that, for the total middle-order services category, 8 of the 17 subregions have above-average levels of rural service infrastructural development (ratio values of more than 1.00), and 9 have below-average levels (ratio values less than 1.00). Similarly, in the total higher-order services category, 6 of the 7 subregions providing high-order services have above-average levels of rural service infrastructural development (Table 11).

The subregions with below-average infrastructural development are those that have gaps in the provision of this rural service infrastructure. The subregions consist of a service center and several settlements; therefore, the gaps that are identified in Tables 9 and 10 are indeed gaps in service provision in the settlements of the subregion. Another angle that could be explored on the basis of the analysis of ratio values is the question of what the ratio values indicate about the stages of development in the study region. Only the ratios of total service provision for the middle-

Table 8—Service scores per square kilometer served for each middle-order service center and the study region

Center and Subregion	Education	Health	Communi-cation	Banking	Transport	Agricultural Inputs and Implements	Animal Husbandry	Marketing	Retail Trade	Total Services
Centers and subregions inside the study region										
Arkonam	0.35	0.76	0.58	0.09	0.53	1.66	0.03	1.68	10.74	16.42
Arni	0.35	0.58	0.53	0.09	0.25	1.33	0.04	0.69	8.44	12.28
Chetpet	0.46	0.41	0.64	0.13	0.37	1.37	0.11	0.98	6.04	10.52
Desur	0.77	1.12	1.16	0.72	0.15	3.74	0.19	2.26	6.68	16.80
Kalasapakkam	2.43	2.66	3.66	2.04	1.17	17.38	0.61	4.02	18.80	52.77
Kannamangalam	0.51	0.74	0.76	0.47	0.67	2.47	0.00	0.96	6.38	12.97
Kaveripakkam	0.39	1.11	0.56	0.24	0.90	1.38	0.07	2.06	15.00	21.70
Kilpennathur	0.29	0.30	0.40	0.19	0.18	1.34	0.05	0.70	3.32	6.78
Nemili	0.48	0.50	0.52	0.41	0.37	2.12	0.09	1.45	5.61	11.55
Panapakkam	0.73	0.84	0.77	0.41	0.20	2.98	0.13	0.91	8.03	14.99
Peranamallur	0.34	0.28	0.51	0.32	0.23	1.99	0.09	1.08	3.64	8.47
Polur	0.32	0.38	0.58	0.08	0.28	1.50	0.06	0.86	6.99	11.05
Thellar	0.49	0.38	0.66	0.39	0.07	2.08	0.09	0.50	3.67	8.33
Thiruvathipuram (Cheyyar)	0.54	0.46	0.64	0.13	0.28	1.43	0.08	1.24	6.23	11.03
Tiruvannamalai	0.49	0.74	0.70	0.10	0.38	1.65	0.08	1.09	10.87	16.09
Vettavalam	0.35	0.22	0.55	0.23	0.13	1.36	0.05	0.84	4.63	8.38
Wandiwash	0.33	0.33	0.53	0.09	0.22	1.33	0.05	0.75	5.22	8.84
Centers and subregions outside the study region										
Kancheepuram	0.32	0.16	0.49	0.05	0.14	1.22	0.04	0.65	3.22	6.31
Solingar	0.28	0.05	0.45	0.05	0.09	1.14	0.00	0.99	3.10	6.15
Tirukovilur	0.35	0.35	1.11	0.00	0.35	2.07	0.00	2.46	7.47	14.15
Tirutani	0.25	0.03	0.47	0.11	0.09	0.78	0.00	0.64	2.29	4.66
Uthramerur	0.16	0.00	0.17	0.00	0.16	1.38	0.00	1.34	3.14	6.34
Average for the study region	0.39	0.51	0.59	0.11	0.30	1.48	0.06	0.99	7.64	12.08

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Information about the service centers outside the study region is incomplete.

Table 9—Ratios of subregional to study region scores for middle-order services

Center and Subregion	Education	Health	Communi-cation	Banking	Transport	Agricultural Inputs and Implements	Animal Husbandry	Marketing	Retail Trade	Total Services
Centers and subregions inside the study region										
Arkonam	0.897	1.490	0.983	0.818	1.767	1.122	1.500	1.697	1.406	1.359
Arni	0.897	1.137	0.898	0.818	0.833	0.899	0.667	0.697	1.105	1.017
Chetpet	1.179	0.804	1.085	1.182	1.233	0.926	1.833	0.990	0.791	0.871
Desur	1.974	2.196	1.966	6.545	0.500	2.527	3.167	2.283	0.874	1.391
Kalasapakkam	6.231	5.216	6.203	18.545	3.900	11.743	10.167	4.061	2.461	4.368
Kannamangalam	1.308	1.451	1.288	4.273	2.233	1.669	0.000	0.970	0.835	1.074
Kaveripakkam	1.000	2.176	0.949	2.182	3.000	0.932	1.167	2.018	1.963	1.796
Kilpennathur	0.744	0.588	0.678	1.727	0.600	0.905	0.833	0.707	0.435	0.561
Nemili	1.231	0.980	0.881	3.727	1.233	1.432	1.500	1.465	0.734	0.956
Panapakkam	1.872	1.647	1.305	3.727	0.667	2.014	2.167	0.919	1.051	1.241
Peranamallur	0.872	0.549	0.864	2.909	0.767	1.345	1.500	1.091	0.476	0.701
Polur	0.820	0.745	0.983	0.727	0.933	1.014	1.000	0.869	0.915	0.915
Thellar	1.256	0.745	1.119	3.545	0.233	1.405	1.500	0.505	0.480	0.690
Thiruvathipuram (Cheyyar)	1.385	0.902	1.085	1.182	0.933	0.966	1.333	1.253	0.815	0.913
Tiruvannamalai	1.256	1.451	1.186	0.909	1.267	1.115	1.333	1.101	1.423	1.332
Vettavalam	0.897	0.431	0.932	2.091	0.433	0.919	0.833	0.848	0.606	0.694
Wandiwash	0.846	0.647	0.898	0.818	0.733	0.899	0.833	0.758	0.683	0.732
Centers and subregions outside the study region										
Kancheepuram	0.821	0.314	0.831	0.455	0.467	0.824	0.667	0.657	0.421	0.522
Solingar	0.718	0.098	0.763	0.455	0.300	0.770	0.000	1.000	0.406	0.509
Tirukovilur	0.897	0.686	1.881	0.000	1.167	1.399	0.000	2.485	0.978	1.171
Tirutani	0.641	0.059	0.797	1.000	0.300	0.527	0.000	0.646	0.300	0.386
Uthramerur	0.410	0.000	0.288	0.000	0.533	0.932	0.000	1.354	0.411	0.525

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Information about the service centers outside the study region is incomplete.

Table 10—Service scores per square kilometer served for each high-order service center and the study region

Center and Subregion	Education	Health	Communi-cation	Banking	Transport	Agricultural Inputs and Implements	Animal Husbandry	Marketing	Retail Trade	Total Services
Centers and subregions inside the study region										
Arkonam	0.31	0.67	0.52	0.08	0.48	1.63	0.03	1.56	9.95	15.24
Arni	0.37	0.74	0.58	0.12	0.30	1.30	0.04	0.74	10.15	14.35
Chetpet	0.97	2.01	1.15	0.57	1.67	2.44	0.27	2.04	17.55	28.67
Polur	0.39	1.17	0.50	0.14	0.73	1.66	0.09	1.82	14.86	21.35
Thiruvathipuram (Cheyyar)	0.96	1.26	0.85	0.22	0.60	1.90	0.09	2.45	12.40	20.75
Tiruvannamalai	0.41	0.54	0.63	0.10	0.29	1.52	0.06	0.94	8.18	12.67
Wandiwash	0.37	0.43	0.50	0.10	0.27	1.35	0.04	0.77	5.95	9.78
Centers and subregions outside the study region										
Kancheepuram	0.35	0.18	0.51	0.08	0.15	1.47	0.05	0.78	3.50	7.07
Madras	0.33	0.18	0.48	0.13	0.15	1.60	0.05	1.04	3.49	7.45
Thindivanam	0.34	0.00	1.10	0.39	0.34	1.37	0.00	2.94	7.73	14.20
Tirutani	0.26	0.05	0.52	0.10	0.11	0.83	0.00	0.93	2.69	5.50
Vellore	0.23	0.08	0.46	0.06	0.10	1.28	0.06	0.48	2.82	5.57
Average for the study region	0.36	0.46	0.56	0.10	0.27	1.45	0.05	0.93	6.85	11.04

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Information about the service centers outside the study region is incomplete.

Table 11—Ratios of subregional to study region scores for high-order services

Center and Subregion	Education	Health	Communi-cation	Banking	Transport	Agricultural Inputs and Implements	Animal Husbandry	Marketing	Retail Trade	Total Services
Centers and subregions inside the study region										
Arkonam	0.861	1.457	0.929	0.800	1.778	1.124	0.600	1.677	1.453	1.380
Arni	1.028	1.609	1.036	1.200	1.111	0.897	0.800	0.796	1.482	1.300
Chetpet	2.694	4.370	2.054	5.700	6.185	1.683	5.400	2.194	2.562	2.587
Polur	1.083	2.543	0.893	1.400	2.704	1.145	1.800	1.957	2.169	1.934
Thiruvathipuram (Cheyyar)	2.667	2.739	1.518	2.200	2.222	1.310	1.800	2.634	1.810	1.880
Tiruvannamalai	1.139	1.174	1.125	1.074	1.074	1.048	1.200	1.011	1.194	1.148
Wandiwash	1.028	0.935	0.893	1.000	1.000	1.000	0.800	0.828	0.869	0.886
Centers and subregions outside the study region										
Kancheepuram	0.972	0.391	0.911	0.800	0.556	1.014	1.000	0.839	0.511	0.640
Madras	0.917	0.391	0.857	1.300	0.556	1.103	1.000	1.118	0.509	0.675
Thindivanam	0.944	0.000	1.964	3.900	1.259	0.945	0.000	3.161	1.128	1.286
Tirutani	0.722	0.109	0.929	1.000	0.407	0.572	0.000	1.000	0.393	0.498
Vellore	0.639	0.174	0.821	0.600	0.370	0.883	1.200	0.516	0.412	0.505

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Information about the service centers outside the study region is incomplete.

order services are examined here, as an example, but each of the other services could be looked at in a similar manner.

As can be seen in Table 9, the ratios of total service provision in the subregions vary. Of the subregions with below-average infrastructural development (values of less than 1.00), there are three subregions (Nemili, Polur, and Thiruvathipuram (Cheyyar) with values of 0.913-0.956; one (Chetpet) with a value of 0.871; two (Peranamallur and Wandiwash) with values of 0.701 and 0.732; two (Thellar and Vettavalam) with values of 0.690 and 0.694, and one (Kilpennathur) with a value of 0.561.

If one were to divide these values into four equal parts, those subregions with values up to 0.249 would be categorized as the most poorly developed infrastructurally; those with values from 0.250–0.499 would be more poorly developed; those with values from 0.500–0.749, poorly developed; and those with values of 0.750–0.999, the least poorly developed subregions. Nevertheless all are "poorly developed" subregions because their ratio values are less than 1.00.

Once the exercise below on median population thresholds is completed, two approaches can be taken to fill in these gaps. In the one termed "equity" approach, the most poorly developed subregions are invested in first and the least poorly developed subregions last. The second, the "efficiency" approach, begins with investment in the least poorly developed subregions first and ends with the most poorly developed subregions.

In geographical terms, the objective of the exercise is to bring all poorly developed subregions up to a ratio of 1.00, thus ensuring overall development of the study region. For the current exercise, however, the efficiency approach, where investment begins with the least poorly developed subregions, is recommended because it is less costly and less time-consuming to bring subregions up from 0.750 to 1.00 than it is to bring them up from 0.249 to 1.00.

The question of how one should go about identifying the settlements in which such gaps exist within the subregions is tackled in the section below on median population thresholds. What these levels of rural service infrastructural development mean for the sample villages and for the sample households in overall availability of and accessibility to these services is briefly noted in the section on the regional context of service provision, later in this chapter.

Determination of Median Population Thresholds

The search for quantitative estimates of the entry level of various services in a regional settlement system is important for settlement studies.[14] The logic of central place theory suggests that such thresholds must exist, but their exact definition remains elusive. One major reason for this elusiveness is the complexity of locational decisions. Services are established in a given settlement for a variety of reasons, of which population size is an important but not necessarily overriding factor. As a result, the simple concept of "entry level" must be replaced by "entry zone," at the lower limits of which all the settlements lack the service, and at the upper limits, all settlements possess it. Therefore, estimates of population thresholds should be designed to include cases where no settlement has a service and, conversely, cases where all settlements have the service.

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[14] This analysis is based on a method used by Haggett and Gunawardena (1964) in rural Ceylon (now Sri Lanka).

The Reed-Muench method of determination of median population thresholds of services is used with some modifications for North Arcot district (Haggett and Gunawardena 1964). This analysis, unlike previous studies, uses the percentage of settlements with or without services rather than their absolute numbers in determining the median population thresholds.

Some 42 services were eliminated from the analysis because too few or too many settlements had these services. For instance, all but 13 settlements have a primary school; at the other extreme, no settlement had a technical or professional college. The list of services eliminated from the analysis is given in Table 12.

For 25 services, both the distribution of settlements and of settlements with services, with respect to population size, appear to be normal enough to calculate median population thresholds with a high degree of confidence (Table 13). This leaves 67 services whose geographical distribution relative to population size did not conform well to the original assumptions. These services are divided into three groups: the first consists of services that are not available in all the settlements with populations above the upper threshold. The second consists of services that almost all settlements have. The final group of services poses a difficult problem because they show a declining tendency for the function to exist in higher population categories, rather than an increasing tendency. Because the number of settlements with larger populations is small, in the final group of services a single settlement having or not

Table 12—Services eliminated from the median threshold analysis

Reason for Elimination	Number of Services	Name of Services
Less than 2.5 percent of the settlements have the service	39	College, pathological and radiological tests, land development bank, transport of goods by road, passenger train service, transport of goods by train, purchase of electric motors, purchase of electric pumpsets, purchase of oil engines, purchase of sugarcane crushers, purchase of sprayers, purchase of dusters, purchse of threshers, servicing of threshers, servicing of tractors, servicing of cage wheels, sale of turmeric, medical shops, glassware, footwear, bicycle retail, timber, hardware, steel furniture, opticals, watch retail, radio retail, transistor sales, scooter repair, automobile repair, petrol, diesel fuel, and lubricants, jewelry, foreign liquor, bookbinding, printing, leather goods, photography
More than 97.5 percent of the settlements have the service	2	Primary school, retail petty shop
Very unreliable distributional data	1	Key village center

Source:

Table 13—Services for which median thresholds were calculated with minor modifications of the assumptions

Service	Median Population Threshold
Middle school	3,180
High school	5,400
Higher secondary school	7,040
Family planning camp	7,510
Private hospital	6,960
Postal order	5,210
Telegrams	6,250
Radio license	4,500
Tractor rental	4,810
Servicing of electric motors	5,210
Servicing of electric pumpsets	5,440
Servicing of oil engines	6,170
Servicing of sprayers	6,190
Servicing of dusters	6,300
Fertilizers and pesticides	5,340
Veterinary dispensaries	6,780
Sale of vegetables	6,510
Sale of bajra	6,730
Sale of jowar	6,290
Sale of pulses	7,370
Retail cloth shop	5,550
Ready-made garments	7,140
Electrical goods	6,780
Wooden furniture	2,950
Sweet shops	6,990

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Median population thresholds are rounded to the nearest 10.

having a service can have a dramatic effect on the overall distribution of services (see Table 14).

These peculiarities in the actual distribution of services in the study region were kept in mind when calculating the median population thresholds of these services. Table 15 shows the number of settlements from the study region that have the required population threshold for a given service, but do not have the service. These locational gaps in the service provision structure can also be seen as potential that needs to be developed before long, in order to strengthen the service delivery system.[15] It is expected that once these gaps are filled, the delivery system itself will be better articulated and be better equipped to serve the study region.

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[15] Some of these services are provided by the government and others by the private sector, and the implications of this analysis are different for each. For the government sector, recommendations regarding some location of services could be made, which would form the basis of a plan for their provision. For the private sector, however, the analysis notes the possible locations for provision of such services. No specific plans for their provision could be made because other factors also govern their locations.

Table 14—Services for which median thresholds were calculated with major modifications of the assumptions

Service	Median Population Threshold
Services with very high threshold values	
Family planning clinic	7,330
Primary health center	7,730
Nationalized bank	8,030
Rental of sugarcane crushers	5,880
Servicing of sugarcane crushers	8,920
Sale of paddy	8,730
Sale of castor	8,430
Sale of groundnuts	8,890
Sale of chilies	8,330
Sale of tamarind	8,580
Household utensils	7,250
Cement	8,650
Lime	7,330
Watch repair	7,990
Radio repair	7,740
Furnishings	8,180
Services with very low threshold values	
Allopathic clinics	3,470
Passenger bus service	2,380
Retailing of tools	1,841
Rental of implements	1,190
Rental of oil engines	3,270
Rental of sprayers	2,040
Rental of dusters	3,060
Rental of threshers	5,940
Rental of cage wheels	5,260
Rental of tools	1,150
Servicing of implements	1,370
Blacksmith	930
Carpenter	960
Cobbler	900
Tea and coffee shop	1,190
Laundry	910
Barber	860
Bakery	1,920
General provisions	2,180
Pottery	1,100
Bicycle repair	1,820
Fuel	1,620
Bricks/tiles	1,570
Stone	2,800
Arrack shop	1,280
Purchase of fruits	2,420
Purchase of poultry products	1,120
Purchase of meat products	1,700
Purchase of dairy products	880
Services with very skewed distributions	
Government hospital	9,720
Postage	1,360
Money order	1,730
Registration	1,750
Telephone	4,860
Primary cooperative credit society	4,330
Lead bank	8,670
Retailing of implements	8,280
Seeds	6,500
Sale of fruits and coconuts	9,420
Sale of other oilseeds	9,480
Sale of sugarcane	10,510
Sale of jaggery	10,510
Sale of firewood	9,027
Stationery	6,520
Retail of vegetables	3,510
Cold drinks	1,290
Restaurants	3,270

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Relationship between Hard and Soft Infrastructural Services

The literature on rural infrastructure implies that the availability in a settlement of soft infrastructural services such as education, health, communications, banking, agricultural inputs, animal husbandry, agricultural marketing, and retail services is dependent on the availability of hard infrastructure such as roads, as well as on the settlement's population. These hypotheses are tested using 15 logit regressions, for which the dependent variable is the availability of a soft infrastructural service in a settlement. The 15 dependent variables (services) include high school, primary health center, government (public rather than private) hospital, post office, telegraph office,

Table 15—Number of settlements having the median threshold population but not having the service

Service	Number of Settlements Lacking the Service
Education services	
Primary school	13
Middle school	12
High school	4
Higher secondary school	2
Health services	
Allopathic clinic	12
Family planning camp (mobile)	2
Family planning clinic	3
Primary health center	2
Private hospital	2
Government hospital	2
Communication services	
Postage	37
Money order	29
Registration	27
Postal order	4
Telegrams	4
Radio license	6
Telephone	6
Banking services	
Primary cooperative credit society	6
National bank	2
Lead bank	1
Transportation service	
Passenger bus service	24
Agricultural input and implement services	
Tools, purchase	51
Implements, rental	3
Tools, rental	69
Implements, purchase	68
Oil engines, rental	15
Sugarcane crushers, rental	5
Sprayers, rental	28
Dusters, rental	19
Threshers, rental	3
Tractors, rental	4
Cage wheel, rental	5
Tools, servicing	49
Implements, servicing	55
Electric motors, servicing	6
Electric pump set, servicing	5
Oil engines, servicing	4
Sugarcane crushers, servicing	3
Sprayers, servicing	4
Dusters, servicing	4
Seeds	2
Fertilizers and pesticides	4
Animal husbandry services	
Veterinary dispensary	2

Service	Number of Settlements Lacking the Service
Marketing services	
Sale of vegetables	3
Sale of fruit	3
Sale of paddy	2
Sale of bajra	2
Sale of jowar	2
Sale of pulses	2
Sale of castor	2
Sale of groundnuts	2
Sale of oil seeds	2
Sale of sugarcane	1
Sale of jaggery	1
Sale of chilies	2
Sale of tamarind	1
Sale of poultry products	24
Sale of dairy products	16
Sale of firewood	2
Retail services	
Blacksmith	41
Carpenter	43
Cobbler	40
Petty shop	11
Tea and coffee shop	2
Laundry	32
Barber	38
Bakery	25
General provisions	28
Ready-made garments	27
Household utensils	3
Pottery	59
Electrical goods	2
Bicycle repair	33
Fuel	53
Bricks/tile	54
Cement	2
Stone	23
Lime	3
Wooden furniture	25
Stationery	2
Bicycle retail	2
Watch repair	2
Radio repair	2
Transistor repair	2
Arrack shops	44
Sweet shops	2
Purchase of vegetables	14
Purchase of fruits	34
Purchase of poultry products	46
Purchase of meat products	50
Purchase of dairy products	34
Cold drinks	21
Restaurant	14

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

lead bank, agricultural implements shop, seeds shop, fertilizer shop, veterinary dispensary, agricultural markets for paddy and groundnuts, cloth shop, electrical goods shop, and furnishing stores, and the independent variables are population of the settlement and the settlement's distance to bus service, which is used as a proxy for the hard infrastructural services such as roads and road networks, and which is itself a direct measure of transportation infrastructure.

The logit function describes a relationship in which the probability of a situation existing rises at an increasing rate with increases in the values of dependent variables until a 50-50 chance is reached and rises at a decreasing rate thereafter. It is assumed that once the value of an independent factor becomes so large that the dependent situation is almost guaranteed, further increases have very little additional effect; similar logic applies as the lower bound is approached. This assumption fits well with the way that factors are expected to contribute to location decisions.

As can be seen from the regression results in Table 16, the variable for distance to a bus stop from the settlement has a negative and statistically significant impact on the availability of 8 of the 15 soft infrastructural services. The sign is in the right direction for the other 7 services but is not statistically significant.[16] However, the population of the settlement has a positive and statistically significant effect on the availability of all the soft infrastructural services.[17] It should be recognized that the coefficients represent the direct effects of access to and population of the settlement on location of the specific service, but also include their indirect effects on location of other services, which may result in greater demand for the specific service through an increase in consumers' income and the area's commerce.

Simulating a 1 kilometer increase in distance to the bus stop (for example, from 0.7 to 1.7 kilometers) for an average size settlement (say, 1,953 persons), the probability of a service being present would change from 12 percent to 6 percent for a high school, from 2 to 1 percent for a primary health center, from 2 to 0 percent for a post office, from 25 to 23 percent for a telegraph office, from 2 to 1 percent for a lead bank, from 11 to 7 percent for a fertilizer shop, from 3 to 1 percent for a veterinary dispensary, and from 4 to 3 percent for groundnut marketing (Table 16).[18] These figures suggest the magnitude of the effect of limited access to transportation infrastructure on location of other services.

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[16] Similar results are observed using probit regressions: the distance to a bus stop has a negative and statistically significant effect on the availability of 5 of the 15 services.

[17] The positive and statistically significant effect of population on the availability of all 15 services is also observed when probit regressions are used.

[18] The base probabilities are derived by calculating $P = 1/[1 + e^{-(a + b_1x_1 + b_2x_2)}]$, using the coefficients presented in Table 16, the mean population in thousands of persons (1,953), and the mean distance in kilometer (0.7). The probabilities after a 1-kilometer increase in distance from the settlement to the nearest bus stop is derived by again calculating P, but replacing the mean distance (0.7) with the greater distance (1.7) and retaining the mean population (1,953). The base equation is

$$P = 1/[1 + e^{-(a + b_1 \times 1{,}953 + b_2 \times 0.7)}].$$

The equation for the greater distance is

$$P = 1/[1 + e^{-(a + b_1 \times 1{,}953 + b_2 \times 1.7)}].$$

Table 16—Logit regression analysis of availability of soft infrastructural services in the study region

Services	Coefficient of Population	Coefficient of Distance to Bus Stop	Constant
	(thousands)	(kilometers)	
High school	0.6576* (5.970)	-0.7652* (-3.512)	-2.7227* (-9.637)
Primary health center	0.5855* (4.808)	-0.8810* (-2.543)	-4.5435* (-9.447)
Government hospital	0.4113* (3.668)	-15.8540 (-0.009)	-4.0106* (-9.414)
Post office	1.0768* (7.057)	-2.8645* (-2.509)	-4.2083* (-10.072)
Telegraph office	0.6621* (6.156)	-0.1352* (-2.470)	-2.2660* (-9.094)
Lead bank	0.5628* (4.800)	-0.7087* (-1.553)	-4.3370* (9.982)
Agricultural implements shop	0.3245* (3.458)	-0.2203 (-1.202)	-3.0815* (10.206)
Seed shop	0.6172* (5.759)	-0.0719 (-0.567)	-3.5128* (11.201)
Fertilizer shop	0.7029* (6.182)	-0.5288* (-2.673)	-3.1320* (-10.275)
Veterinary dispensary	0.6165* (5.234)	-0.8380* (-2.068)	-3.9492* (-10.233)
Agricultural marketing of paddy	0.4426* (4.280)	-0.3862 (-1.355)	-3.8180* (-10.268)
Agricultural marketing of groundnuts	0.4193* (4.086)	-0.3933* (-2.357)	-3.7516* (-10.199)
Cloth shop	1.0372* (6.506)	-17.7240 (-0.011)	-4.3250* (-9.637)
Electrical goods shop	0.9468* (5.472)	-16.3010 (-0.010)	-5.2490* (8.873)
Furnishings shop	0.5918* (4.636)	-15.4850 (-0.009)	-4.8210* (-9.176)

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Numbers in parentheses are t-statistics.
*Difference from zero is significant at the 0.05 level.

Regional Context of Service Provision

Analysis of regional patterns has shown that a hierarchy of soft and hard infrastructural service provision underlies the hierarchy of settlements in the study region. This has given rise to three distinct levels of service centers and spatial interaction between settlements. The analysis has also shown that there are different levels of development of soft and hard infrastructural services even within the subregions of the study region. Which services are above or below the average for rural service infrastructural development can be identified not only for the total but also for individual services. Finally, the analysis has shown that poor access to hard infrastructural services in a settlement influences negatively and significantly the availability of soft infrastructural services, and it has also shown that population of the settlement influences positively and significantly the availability of soft infrastructural services.

It is fair to expect that a sample village located in a subregion with above-average infrastructural development would have an advantage over one not so favorably located. All the sample villages, for example, are low-order service centers in their own right. For middle- and high-order services, however, they interact with one or more larger service centers. For example, Vegamangalam is served by Kaveripakkam for middle-order services and by Kancheepuram for high-order services, but Nesal is served by Arni for both middle- and high-order services. In this sense, the sample villages "belong" to certain service centers in the study region. Further, the inhabitants of Nesal village do not have to travel a greater distance than those of Vegamangalam to use the services available in their respective service centers. In addition, the ranking of service centers themselves, at the middle and high levels of service hierarchy, adds to the totality of the regional infrastructural context as far as the sample villages are concerned. For example, Kaveripakkam is a less important service center than Arni at the middle level of the service hierarchy. Therefore, in a regional infrastructural context, Nesal village is superior to Vegamangalam, which makes a great deal of difference in overall availability of and access to services for the inhabitants of these villages.

Central Place Theory and Provision of Services in the Study Region

The foregoing analysis of regional provision and use of services at the settlement level has demonstrated that the principles of central place theory apply to the study region. In the study region, there is a hierarchy of central functions (services) that underlies and explains the hierarchy of central places (service centers). There are complementary regions (subregions) of central places, where the highest order (most important) central place has the greatest number of central functions, the largest service population, and the largest number of smaller central places (dependent settlements) served.

The highest-order central place thus provides all the central functions of the lower-order central places and also provides one or more of the higher-order central functions, which clearly distinguish it from the lower-order central places.

In addition to identifying the high-order central places with a centrality surplus and their centrality-deficit complementary regions, the analysis also finds that between the complementary regions there are centrality-surplus and centrality-deficit subregions.

The analysis has also demonstrated that there are no hexagonal complementary regions and that the number of lower-order central places that exist for each of the higher-order central places is determined by the interplay of marketing and transport principles at the lower levels of the central place hierarchy, and by the interplay of marketing, transport, and adminstrative principles of the central place theory at the higher levels of the central place hierarchy.

Further, the analysis shows that there is a *range* of central functions (area served by the services) and a *threshold* of central functions (median population necessary to support a service) for all central functions in the study region.

Finally, the analysis has demonstrated that the structure of provision of central functions (services) in the study region has implications for access to them as far as the settlements and the households in the study region are concerned. This access can (and as it will be seen in the next chapter, does) influence the pattern of consumption of the central functions in the study region.

There are two important differences in the approaches taken by the central place theory of Christaller and by this study. The less important of the two, theoretically, is the choice of the study region. Christaller bases his study on the rural regions of southern Germany in the early 1930s: this study is based on the rural regions of southern India in the early 1980s. But the nature of the studies themselves constitutes the more important difference. Christaller's formulation is deductive, proceeding from the top to the bottom, whereas this study is inductive, using grassroots data to identify the structure of the central place hierarchy and system in the study region.

5

HOUSEHOLD PATTERNS OF SERVICE USE

Household use of services depends upon a variety of factors such as distance to services, types of households, their socioeconomic status, and the end use of the services. This chapter aims to understand how households in the study region use services and attempts to integrate these findings with those of the previous chapter to identify locational priorities for investment in rural service infrastructure in the study region.

Sample Households, Sample Villages, and Services

According to an earlier study, the socioeconomic status of a household, as well as the distance to services, influences a household's pattern of use of services in a variety of ways (Wanmali 1985). In that study, however, no data were available on household expenditure patterns to estimate the impact of access on a household's use of services. This finding is investigated here with the help of expenditure data from 11 sample villages of the study region.

The four types of households included in the study use the following number of services from a total number of 134: paddy farm operator, 105; nonpaddy farm operator, 75; cultivation laborer, 77; and noncultivator, 79. The use of these services in the villages wherein the households are located is diverse.

Five villages—Amudur, Kalpattu, Nesal, Veerasambanur, and Vengodu—have a better than average regional service provision structure (Table 17). To obtain various input, output, and transportation services, the sample households have to travel various distances from the village (Table 18).

Such measures of socioeconomic status as family size, per capita land cultivated, land irrigated, access to credit, value of livestock owned, average value of household goods and agricultural implements, and average expenses were found to be directly correlated with the size of an operational landholding in the previous study (Wanmali 1985). In the following descriptive analysis, therefore, the household's involvement in cultivation is considered to be a proxy for the socioeconomic status of the household.

Geographical Relationships of Patterns of Service Use

Tables 19-22 capture in detail the patterns of use of groups of services of the four types of households. Mean frequency of use of each service group, mean

Table 17—Location of services used by sample villages

Sample Village	Number of Services Within Village	Number of Services Outside Village	Percent of Services Located Outside Village
Amudur	45	42	48.28
Duli	31	67	68.37
Kalpattu	54	45	45.45
Meppathurai	39	52	57.14
Nesal	54	63	53.85
Sirungathur	34	59	63.44
Vayalur	34	65	65.66
Veerasambanur	43	33	43.42
Vegamangalam	47	59	55.66
Vengodu	51	34	40.00
Vinayagapuram	37	56	60.22

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

distance traveled, and the number of households using the services are included. There is sometimes an inverse relationship between mean frequency of use of services and the mean distance to services.

When the use of individual services within the major groups of services is categorized by type of household (Table 23), it can be seen that some services are heavily used by all households—farm or nonfarm. These services include primary schools, allopathic clinics, primary health centers, government hospitals, postage, primary cooperative credit societies, bus transport, retail petty shops, retail cloth shops, tea and coffee shops, barber shops, general provision shops, household utensil shops, medical shops, lime shops, pottery shops, fuel shops, furnishings shops, vegetable shops, meat shops, cold drinks shops, and restaurants. As is

Table 18—Distance to nearest input and output markets and bus stop, by sample village

Sample Village	Seed Distributor	Fertilizer Distributor	Credit Lender	Output Buyer	Bus Stop
			(kilometers)		
Amudur	10.0	15.0	15.0	10.0	4.0
Duli	6.2	6.4	5.0	5.0	1.0
Kalpattu	8.0	15.0	15.0	8.6	1.0
Meppathurai	6.4	17.0	17.0	6.4	2.0
Nesal	6.5	10.5	6.5	6.5	2.0
Sirungathur	7.0	7.0	7.0	7.0	0.7
Vayalur	6.4	19.0	17.0	6.4	1.0
Veerasambanur	7.0	17.0	15.0	7.0	1.0
Vegamangalam	6.0	18.0	6.0	6.0	3.0
Vengodu	9.5	17.0	17.0	10.0	6.5
Vinayagapuram	11.5	13.0	13.0	13.0	3.0

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Table 19—Mean frequency of service use, number of households using service, and mean distance traveled to service, paddy farm households

	Education		Health		Communication		Banking		Transport		Agro-Inputs		Animal Husbandry		Marketing		Retail		Total	
Distance	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households
(kilometers)																				
< 2	192.45	35	11.13	52	8.23	41	2.55	37	39.00	51	12.98	51	1.70	31	92.30	50	657.49	53	113.09	53
2 - 4	255.00	30	14.08	40	14.00	32	3.50	27	53.03	39	14.45	38	1.95	28	130.18	38	686.13	40	130.26	40
4 - 6	193.10	19	13.86	29	17.00	24	4.62	21	66.41	29	13.86	29	1.97	23	44.93	29	688.69	29	116.05	29
> 6	268.75	26	12.03	32	12.41	22	8.31	20	72.13	31	17.88	32	2.38	26	128.78	32	669.50	32	132.46	32

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Mean use represents the mean number of times a service is used per year.

Table 20—Mean frequency of service use, number of households using service, and mean distance traveled to service, nonpaddy farm households

	Education		Health		Communication		Banking		Transport		Agro-Inputs		Animal Husbandry		Marketing		Retail		Total	
Distance	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households
(kilometers)																				
< 2	160.00	5	9.50	10	8.40	8	1.40	6	34.90	10	4.60	8	0.50	2	1.60	7	618.00	10	93.21	10
2 - 4	233.33	5	23.83	6	5.83	4	4.50	3	68.83	5	4.67	6	1.00	3	0.83	4	773.17	6	124.00	6
4 - 6	300.00	5	16.17	6	15.33	6	0.33	2	46.17	6	6.67	5	0.83	3	118.00	6	730.33	6	137.09	6
> 6	400.00	2	22.50	2	11.00	2	1.00	1	52.00	1	6.00	2	2.00	1	51.00	2	759.00	2	144.94	2

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Mean use represents the mean number of times a service is used per year.

Table 21—Mean frequency of service use, number of households using service, and mean distance traveled to service, cultivation laborer households

Distance	Education		Health		Communication		Banking		Transport		Agro-Inputs		Animal Husbandry		Marketing		Retail		Total	
	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households
(kilometers)																				
< 2	100.00	27	17.50	67	5.50	49	0.10	4	20.68	65	1.41	32	0.76	15	36.32	12	620.34	68	89.18	68
2 - 4	142.86	7	6.36	13	7.57	9	0.21	2	20.57	14	3.79	8	0.50	3	40.14	6	874.36	14	121.82	14
4 - 6	122.22	17	8.08	36	6.64	20	0.17	3	25.33	36	1.92	14	0.61	11	22.14	8	560.75	36	83.10	36
> 6	200.00	2	8.75	4	10.50	3	5.50	2	71.75	4	3.00	1	1.50	1	100.50	2	613.00	4	112.72	4

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Mean use represents the mean number of times a service is used per year.

Table 22—Mean frequency of service use, number of households using service, and mean distance traveled to service, noncultivator households

Distance	Education		Health		Communication		Banking		Transport		Agro-inputs		Animal Husbandry		Marketing		Retail		Total	
	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households	Mean Use	Number of Households
(kilometers)																				
< 2	94.12	6	6.29	17	14.82	10	0.18	2	41.82	16	0.71	5	0.18	2	29.41	2	674.88	17	95.82	17
2 - 4	88.89	4	8.44	9	3.11	6	0.00	...	53.89	9	0.89	3	0.00	...	22.00	2	946.33	9	124.84	9
4 - 6	288.89	8	12.33	9	14.56	9	2.67	2	88.00	9	2.56	3	0.78	3	233.67	3	872.89	9	168.48	9
> 6	100.00	1	7.50	2	3.50	2	0.00	...	42.00	2	0.00	...	0.00	...	0.00	...	492.50	2	71.72	2

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: Mean use represents the mean number of times a service is used per year.

Table 23—Percentage of households using each service, by household type

Service	Households Using Service			
	Paddy Farm Operator	Nonpaddy Farm Operator	Cultivation Laborer	Non-cultivator
	(percent)			
Primary school	66.57	59.00	37.25	51.61
Middle school	21.26	20.00	9.80	12.90
High school	22.05	20.00	2.94	6.45
Higher secondary school	2.36	5.00	0.98	3.23
College	3.94	0.00	0.98	0.00
Technical institute	0.00	0.00	0.00	0.00
Professional college	0.00	0.00	0.00	0.00
Allopathic clinic	46.46	40.00	46.08	54.84
Family planning camp (mobile)	0.00	0.00	0.00	0.00
Family planning clinic	0.00	0.00	0.98	0.00
Primary health center	37.01	30.00	35.29	22.58
Private hospital	74.80	55.00	27.45	51.61
Government hospital	66.14	65.00	70.59	70.97
Pathological and radiological tests	3.15	0.00	0.00	0.00
Postage	75.59	80.00	64.71	74.19
Money order	3.15	5.00	1.96	0.00
Registration	5.51	0.00	1.96	6.45
Postal order	1.57	0.00	0.98	0.00
Telegram	1.57	0.00	0.00	3.23
Radio license	9.45	5.00	0.98	9.68
Telephone	1.57	0.00	0.00	3.23
Primary cooperative credit society	60.63	40.00	1.96	3.23
Land development bank	18.11	5.00	0.00	0.00
Agriculture/cooperative bank	1.57	0.00	0.98	0.00
Commercial bank	5.51	0.00	0.98	0.00
Nationalized bank	14.17	10.00	1.96	6.45
Lead bank	10.24	5.00	3.92	0.00
Passenger bus service	99.21	95.00	97.06	96.77
Transport of goods by road	0.00	0.00	0.00	0.00
Passenger train service	10.24	5.00	4.90	3.23
Transport of goods by train	0.00	0.00	0.00	0.00
Purchase				
Tools	94.49	50.00	21.57	19.35
Implements	77.17	40.00	30.39	19.35
Electric motors	0.00	0.00	0.00	0.00
Electric pump sets	0.79	0.00	0.00	0.00
Oil engines	0.79	0.00	0.00	0.00
Sugarcane crushers	0.79	0.00	0.00	0.00
Sprayers	0.00	0.00	0.00	0.00
Dusters	0.00	0.00	0.00	0.00
Threshers	0.00	0.00	0.00	0.00
Tractors	0.00	0.00	0.00	0.00
Cage wheel	0.00	0.00	0.00	0.00
Purchase of seeds	88.98	45.00	4.90	3.23
Purchase of fertilizers	93.70	45.00	4.90	3.23
Rental				
Tools	14.96	20.00	2.94	0.00
Implements	16.54	35.00	1.96	0.00
Oil engines	0.00	0.00	0.00	0.00
Sugarcane crushers	0.79	0.00	0.00	0.00
Sprayers	85.04	15.00	4.90	3.23
Dusters	0.00	0.00	0.00	0.00

(continued)

Table 23—Continued

Service	Households Using Service			
	Paddy Farm Operator	Nonpaddy Farm Operator	Cultivation Laborer	Non-cultivator
	(percent)			
Threshers	12.60	0.00	0.98	0.00
Tractors	11.81	5.00	0.00	0.00
Cage wheel	3.15	0.00	0.98	0.00
Service				
Tools	92.91	50.00	16.67	19.35
Implements	75.59	30.00	31.37	19.35
Electric motors	39.37	5.00	0.00	0.00
Electric pump sets	39.37	10.00	0.98	3.23
Oil engine	8.66	0.00	0.00	0.00
Sugarcane crushers	0.79	0.00	0.00	0.00
Sprayers	0.79	0.00	0.00	0.00
Dusters	0.00	0.00	0.00	0.00
Threshers	0.00	0.00	0.00	0.00
Tractors	0.79	0.00	0.00	0.00
Cage wheel	0.00	0.00	0.00	0.00
Key village centers	15.75	15.00	3.92	3.23
Veterinary dispensary	61.42	25.00	21.57	12.90
Sale of				
Vegetables	9.45	5.00	0.00	0.00
Fruits	5.51	0.00	0.00	0.00
Paddy	90.55	15.00	4.90	3.23
Bajra	0.79	5.00	0.00	0.00
Jowar	3.15	0.00	0.00	0.00
Pulses	5.51	5.00	0.00	0.00
Castor	1.57	0.00	0.00	0.00
Groundnut pods	88.19	75.00	4.90	3.23
Other oilseeds	7.87	0.00	0.00	0.00
Sugarcane	4.72	0.00	0.00	0.00
Jaggery	0.79	0.00	0.00	3.23
Chilies	10.24	10.00	0.00	3.23
Turmeric	3.94	0.00	0.00	3.23
Tamerind	0.00	0.00	0.00	3.23
Poultry products	2.36	0.00	0.00	0.00
Dairy products	24.41	10.00	4.90	9.68
Firewood	0.00	0.00	9.80	9.68
Blacksmith	86.61	65.00	28.43	12.90
Carpenter	66.14	35.00	4.90	6.45
Cobbler	33.86	15.00	5.88	16.13
Petty shop	97.64	100.00	100.00	93.55
Retail cloth shop	98.43	95.00	99.02	96.77
Tea and coffee shop	45.67	60.00	63.73	67.74
Laundry	76.38	70.00	33.33	35.48
Barber	91.34	95.00	80.39	87.10
Bakery	50.39	40.00	30.39	45.16
General provisions	98.43	100.00	98.04	96.77
Ready-made garments	49.61	35.00	33.33	54.84
Household utensils	66.93	55.00	57.84	58.06
Medical shop	73.23	65.00	42.16	64.52
Glassware	18.90	15.00	10.78	9.68
Pottery	95.28	95.00	93.14	90.32
Electrical goods	58.27	20.00	20.59	19.35
Footwear	44.09	35.00	18.63	35.48
Bicycle sales	0.00	0.00	0.00	0.00
Bicycle repair	20.47	10.00	5.88	12.90
Timber	0.79	0.00	0.98	0.00

(continued)

Table 23—Continued

Service	Households Using Service			
	Paddy Farm Operator	Nonpaddy Farm Operator	Cultivation Laborer	Non-cultivator
	(percent)			
Fuel	90.55	95.00	82.35	93.55
Bricks/tiles	0.79	0.00	0.98	0.00
Cement	0.00	0.00	0.00	0.00
Stone	0.79	0.00	0.00	0.00
Lime	77.17	85.00	63.73	48.39
Hardware	62.99	5.00	5.88	16.13
Wooden furniture	0.00	0.00	0.00	0.00
Steel furniture	0.00	0.00	0.00	0.00
Opticals	0.00	0.00	0.00	0.00
Stationery	42.52	35.00	11.76	16.13
Watch sales	0.00	0.00	0.00	0.00
Watch repair	10.24	0.00	1.96	0.00
Radio sales	0.79	0.00	0.00	3.23
Radio repair	3.94	0.00	0.00	3.23
Transistor sales	0.00	0.00	0.00	0.00
Transistor repair	7.87	0.00	0.98	3.23
Scooter repair	0.00	0.00	0.00	0.00
Automobile repairs	0.00	0.00	0.00	0.00
Petrol, diesel fuel, lubricants	9.45	5.00	0.98	3.23
Jewelry	0.00	5.00	0.00	0.00
Furnishings	62.20	65.00	69.61	61.29
Arrack shop	23.62	35.00	38.24	41.94
Foreign liquor	6.30	0.00	0.00	3.23
Bookbinding	4.72	0.00	0.98	3.23
Printing	0.00	0.00	0.00	0.00
Sweet shop	33.07	25.00	5.88	16.13
Leather goods	3.15	0.00	0.98	0.00
Photography	3.15	0.00	0.98	0.00
Purchase of vegetables	89.76	100.00	98.04	96.77
Purchase of fruits	74.02	70.00	57.84	54.84
Purchase of poultry	18.90	10.00	17.65	16.13
Purchase of meat products	81.10	95.00	84.31	83.87
Purchase of dairy products	28.35	30.00	6.86	25.81
Cold drinks	57.48	55.00	50.00	61.29
Restaurants	65.35	60.00	54.90	67.74

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

expected, high-order services, which cost more, are used more by farm than nonfarm households. All agriculture-related services are also used largely by farm operators, but especially by paddy farm operators. Although all of these services are available in nearby service centers, not all of them are used by all households in equal measure.

Geographical Determinants of Service Use

In an earlier study, it was hypothesized that the frequency of use of services was influenced not only by the socioeconomic status of the households but also by geographical factors such as the distance at which services are located from the household (Wanmali 1985). That study also noted that a more relevant indicator of service use than frequency of use, such as expenditure, would help to refine the analysis of the impact of access to services on household expenditure. In this section, this relationship is examined with the help of data on household spending on production and consumption goods and services.

In a separate survey of sample households, in which monthly data on income and expenditure were collected, details were obtained on several items of household expenditure (Hazell and Ramasamy 1991). These items sometimes form a complete set and sometimes only a part of the services considered in the present study. The analysis looks at household expenditures on consumption and production services, as well as on revenue from marketed crops. Consumption data were available from the monthly survey of expenditure for services, whereas data were available for only three production-related services: fertilizers, seeds, and credit. Data on revenue from marketed crops also came from the separate survey of sample households in the study region.

Grouping of Services

In order to determine what the expenditure patterns are and to predict responsiveness to changes in distance (measured by expenditure shifts), regression models are developed. Using data on expenditure and household characteristics, the models consider 35 services, grouped to examine distance and expenditure relationships. Low-, middle-, and high-order services form the geographical hierarchy set, and food and personal, consumer durables, health, and transportation services form the economic services set (Table 24). Both sets include the same 35 services, so considerable overlaps occur. This grouping of services, as well as some of the independent variables, is also based on geographical and not merely economic characteristics of services and settlements (see Table 25).

At this point, the reader must be reminded that, for the reasons given in Chapter 2, there is no information on prices of goods and services. Moreover, there is no point in including prices for inputs and outputs because the government administers prices for all of these goods, and the private sector sets its prices very close to the government-administered prices. The results of the analysis, therefore, need to be viewed with this qualification in mind.

The expenditure patterns of the two sets of services were calculated separately in order to obtain a clearer idea of the overlap that exists between them (Table 26). Both analyses cover the four types of households.

Expenditure Share Regressions

Dependent and Independent Variables. For each equation, the dependent variable is the budget share of expenditure for those services, rather than simply the expenditure incurred. This method avoids the estimation problems associated with heteroscedasticity, the increased variability that often occurs with increased total expenditures. Many household characteristics are included to help explain the expenditure patterns (Tables 25 and 27). The percent of households owning various types of vehicles in the village is included to reflect the effects on expenditure patterns of accessibility to various modes of transport (with differing speeds, ranges, and carrying capacities). This method lessens the chance of confusing

Table 24—Definition of service groups for budget share regressions

Service Group	Component Services	
Geographical hierarchy grouping		
Low order	Allopathic clinic	Fuel
	Bus stop	Arrack shop
	Petty shop	Purchase of vegetables
	Tea and coffee shop	Purchase of fruits
	Laundry	Purchase of poultry
	Barber	Purchase of meat
	Bakery	Cold drinks
	General provisions	Restaurant
Middle order	Passenger train service	Hardware
	Retail cloth shop	Wooden furniture
	Ready-made garments	Steel furniture
	Household utensils	Stationery
	Medical shop	Jewelry
	Electrical goods	Furnishings (mattresses)
	Footwear	Sweet shop
High order	Bicycle sales	Transistor sales
	Watch sales	Petrol, diesel, and lubricants
	Radio sales	
Economic services grouping		
Food and personal	Retail petty shop	Arrack shop
	Tea and coffee	Sweet shop
	Laundry	Purchase of vegetables
	Barber	Purchase of fruits
	Bakery	Purchase of poultry
	General provisions	Purchase of meat
	Medical shop	Cold drinks
	Fuel	Restaurant
Consumer durables	Retail cloth shop	Stationery
	Ready-made garments	Watch sales
	Household utensils	Radio sales
	Electrical goods	Transistor sales
	Footwear	Petrol, diesel, and lubricants
	Bicycle sales	Jewelry
	Hardware	Furnishings (mattresses)
	Wooden furniture	
	Steel furniture	
Health	Allopathic clinic	
Transportation	Bus stop	
	Passenger train service	

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

accessibility with household wealth, which might occur if each household's ownership of vehicles was measured. The distance to the nearest bus stop from the village is used as a measure of access to services. It is expected that expenditures for some services might be negatively influenced by poor access (longer distance) to bus services. An irrigation dummy variable is also included to reflect the influence of village agricultural conditions. The equations are estimated by two-

Table 25—Variables included in the expenditure share regressions

Variable	Definition
Dependent	
E	Per capita total expenditure (Rs)
LOWSHR	Low-order expenditure share
MIDSHR	Middle-order expenditure share
HIGHSHR	High-order expenditure share
FPSHR	Food and personal expenditure share
CDSHR	Consumer durables expenditure share
TRANSHR	Transport expenditure share
HEALSHR	Health expenditure share
Independent	
LOGE	Natural log of per capita total expenditure (Rs)
N	Household size (number of members)
LANDPER	Land owned per capita (hectares)
SEX	Sex of head of household (male = 1, female = 0)
ED	Education of household head (1 = above elementary)
PNADULT	Nonadults as percent of household members
PCH_HH	Young child as percent of household members
AGEHH	Age of household head (years)
CYCLE	Percent of households in village owning bicycles
CAR	Percent of households in village owning cars
MOTORCYC	Percent of households in village owning motorcycles or mopeds
TDIS	Distance to nearest bus stop (kilometers)
LDIS	Distance to nearest low-order service (kilometers)
IRRIDUM	Better irrigated village (yes = 1, no = 0)
PPDUM[a]	Paddy farm operator (yes = 1, no = 0)
NPDUM[a]	Nonpaddy farm operator (yes = 1, no = 0)
CLDUM[a]	Cultivation laborer (yes = 1, no = 0)

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

[a] Dummy variables are only used for regressions run on a weighted aggregation of samples.

Table 26—Per capita expenditures on service groups and share of total expenditure, by type of household

Service Group	Paddy Farm Operator		Nonpaddy Farm Operator		Cultivation Laborer		Noncultivator	
	Expenditure	Share	Expenditure	Share	Expenditure	Share	Expenditure	Share
	(Rs)	(percent)	(Rs)	(percent)	(Rs)	(percent)	(Rs)	(percent)
Geographical grouping								
Low order	405.0	56.0	626.0	83.0	477.0	89.0	694.0	88.0
Middle order	95.0	9.0	187.0	8.0	23.0	4.0	66.0	7.0
High order	3.8	0.3	0.0	0.0	2.7	0.3	3.7	0.4
Economic grouping								
Food and personal	376.0	53.0	600.0	80.0	469.0	87.0	668.0	86.0
Consumer goods	96.0	9.0	185.0	7.0	25.0	4.0	62.0	7.0
Transportation	21.5	2.5	15.8	2.2	6.5	1.3	28.1	2.6
Health services	6.5	1.1	5.8	1.6	1.9	0.4	3.8	0.6

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Table 27—Mean values of key variables included in the regressions, by type of household

Variable Description	Paddy Farm Operator	Nonpaddy Farm Operator	Cultivation Laborer	Non-cultivator
Per capita total expenditure (Rs)	752.90	874.32	550.32	789.78
Low-order expenditure share (percent)	56.15	83.17	88.56	87.68
Middle-order expenditure share (percent)	8.98	7.75	3.76	7.13
High-order expenditure share (percent)	0.31	0.00	0.25	0.43
Food and personal expenditure share (percent)	52.86	79.79	87.25	85.57
Consumer durables expenditure share (percent)	8.88	7.33	3.71	6.54
Transport expenditure share (percent)	2.58	2.24	1.27	2.56
Health expenditure share (percent)	1.12	1.58	0.37	0.57
Household size (number of members)	6.42	4.60	4.50	4.19
Land owned per capita (hectares)	0.78	0.30	0.01	0.01
Nonadult as percent of household members	0.35	0.28	0.28	0.30
Young child as percent of household members	0.32	0.24	0.35	0.40
Age of household head (years)	48.78	49.25	47.20	47.45
Sex of head of household (male = 1, female = 0)	0.94	0.90	0.79	0.77
Education of household head (1 = above elementary)	0.48	0.30	0.21	0.48
Distance to nearest bus stop	2.82	2.79	3.05	2.58
Distance to nearest low-order service	1.88	1.32	1.03	1.68
Percent of households in village owning bicycles	0.60	0.51	0.62	0.62
Percent of households in village owning cars	0.01	0.02	0.02	0.02
Percent of households in village owning motorcycle/mopeds	0.01	0.00	0.00	0.01
Better irrigated village (yes = 1, no = 0)	0.50	0.60	0.57	0.61

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

stage, least-squares regressions. All the equations are modifications of the Working-Lesser variation of the Engel function (Hazell and Roëll 1983):

$$E_i = \beta_i E + \delta_i E \ln E + \Sigma\lambda_{ij} E Z_j,$$

which is equivalent to

$$S_i = E_i/E = \beta_i + \delta_i \ln E + \Sigma\lambda_{ij} Z_j,$$

where

E_i is the per capita expenditure on an item,
E is total per capita expenditure,
Z_j is a household, village, access, or distance characteristic,
S_i is an item's share of total per capita expenditure, and
β, δ, and λ are coefficients.

If multicolinearity results from the inclusion of income and factors that have both direct effects on expenditure and indirect effects on expenditure through income, the accuracy of the estimates may suffer; this may be a necessary shortcoming of using an Engel function to examine the effects of infrastructure. However, pairwise correlations do not indicate the existence of multicolinearity in the expenditure share regressions. As a check on the conclusions drawn from the Engel function, findings from the estimation of reduced-form equations are presented in Appendix 1.[19] By excluding the variable representing total expenditure, the previously mentioned problem of multicolinearity is eliminated. However, to separate income effects from other effects, only results from the Engel function are presented in the main text.

Interpretation of Regression Results. Statistically significant, two-stage, least-squares regression results are presented in Table 28 for paddy farm operators and Table 29 for nonpaddy farm operators. Separate regressions estimated for cultivation laborers and noncultivators are not statistically significant (insignificant F-value). The first-stage estimation results for per capita total expenditure (in natural log form) for each of the four household types is presented in Table 30. However, estimation of the Engel functions, using a weighted aggregation of all household types to transform sample proportions into an approximation of population proportions (roughly one-third farm operators, one-third cultivation laborers, and one-third noncultivators), indicates some statistically significant differences between the expenditure patterns of the four types of households. Budget share regressions are estimated for a weighted aggregation of samples include dummy variables for paddy farm operator (PPDUM), nonpaddy farm operator (NPDUM), and cultivation laborer (CLDUM) in place of per capita land owned, in order to contrast the expenditure patterns of noncultivation-oriented households with various types of cultivation-oriented households (see Appendix 2, Table 45 and Table 46, which includes the first-stage estimation results for the natural log of per capita expenditure by household type).

For nonpaddy farm households, only the share of consumer durables (including clothing) proves to be a constant proportion of total expenditure, as evidenced by a statistically significant intercept term. None of the intercept estimates are statistically significant for paddy farm regressions.

Statistically significant t-ratios for the natural log of total per capita expenditure are associated with middle-order goods and services, consumer durables, and transportation for nonpaddy farmers. As per capita income of nonpaddy farm households rises, expenditures on middle-order goods and services and consumer durables tend to increase, while expenditures on transportation decrease. These households consider consumer durables and middle-order goods and services to be superior and transportation inferior. No signs of inferiority or superiority are uncovered with the paddy farm regressions.

Nonpaddy farm households with more land owned per household member, all else being equal, tend to spend a smaller share on low-order goods and services, including purchased food and personal items, and a larger share on health goods and services. This indicates that, at least for nonpaddy farmers, land acquisition allows more food to be consumed from own production and frees cash earnings for

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[19] Ideally, simultaneous estimation of Tobit equations should be conducted, but computer software was not available for Tobit models containing more than two equations.

Table 28—Regression coefficients for budget share equations, by service group, for paddy farm operators

Independent Variable	Dependent Variable LOWSHR	 MIDSHR	 HIGHSHR	 FPSHR	 CDSHR	 TRANSHR	 HEALSHR
Constant	59.973 (0.173)	390.877 (0.618)	-32.773 (-0.640)	-28.038 (-0.069)	310.190 (0.565)	182.320 (0.812)	-28.801 (-0.668)
LOGE	5.1225 (0.099)	-57.5210 (-0.607)	4.7708 (0.622)	17.552 (0.289)	-45.478 (-0.553)	-26.903 (-0.800)	4.5304 (0.701)
N	-0.7618 (-0.507)	-1.3705 (-0.499)	0.1853 (0.834)	-0.4319 (-0.246)	-1.0083 (-0.423)	-0.8090 (-0.831)	0.2375 (1.270)
LANDPER	-7.5505 (-0.567)	16.0718 (0.661)	-0.6983 (-0.355)	-11.235 (-0.721)	13.241 (0.627)	7.0730 (0.819)	-0.6014 (-0.363)
PNADULT	0.4366 (0.023)	-27.2643 (-0.793)	0.6818 (0.245)	3.8893 (0.176)	-24.2340 (-0.812)	-8.3361 (-0.683)	1.6301 (0.696)
PCH_HH	6.6197 (0.625)	1.7339 (0.090)	1.4327 (0.915)	5.4190 (0.437)	2.3657 (0.141)	0.1627 (0.024)	2.0992 (1.592)
AGEHH	-0.0113 (-0.066)	0.1310 (0.420)	-0.0263 (-1.043)	-0.0320 (-0.160)	0.0921 (0.341)	0.0836 (0.756)	-0.0407 (-1.917)*
SEX	0.0819 (0.015)	0.8307 (0.082)	0.9046 (1.107)	0.9291 (0.144)	1.7529 (0.200)	-1.5428 (-0.431)	0.3446 (0.501)
ED	-4.7138 (-0.531)	12.8999 (0.795)	-1.1830 (-0.901)	-7.6820 (-0.739)	10.3030 (0.732)	6.1208 (1.064)	-1.1542 (-1.044)
IRRIDUM	-5.3558 (-1.044)	3.8497 (0.410)	-0.0470 (-0.062)	-5.3830 (-0.895)	3.1573 (0.388)	0.8358 (0.251)	0.3251 (0.509)
CYCLE	-50.617 (-1.844)*	-27.5131 (-0.548)	3.6479 (0.898)	-40.670 (-1.265)	-21.326 (-0.490)	-14.842 (-0.834)	1.3636 (0.399)
CAR	78.365 (0.703)	-115.711 (-0.568)	15.958 (0.968)	78.297 (0.600)	-86.449 (-0.489)	-38.283 (-0.530)	19.864 (1.431)
MOTORCYC	64.959 (0.113)	544.005 (0.517)	-54.903 (-0.644)	-24.590 (-0.036)	425.530 (0.466)	249.880 (0.669)	-74.010 (-1.032)
TDIS	2.4156 (3.352)*	-0.6061 (-0.460)	-0.0972 (-1.912)*	2.3323 (2.762)*	-0.6302 (-0.551)	0.0555 (0.119)	-0.1088 (-2.212)*

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: The sample size of paddy farm operators is 154. The numbers in parentheses are t-ratios. The first stage of the two-stage, least-square regression is presented in Table 30. See Table 25 for definitions of the variables.

* Significant at the 0.10 level (two-tailed test).

health-related expenditures. Again, statistically significant effects are not apparent for paddy farmers.

The age composition of the household also matters for nonpaddy farmers. The larger the share of nonadults in the household, the smaller the portion of per capita expenditure allocated to low-order goods and services, purchased food and personal items, and transportation. Conversely, the larger the share of young children in the household, the larger the shares of expenditures on low-order goods and

Table 29—Regression coefficients for budget share equations, by service group, for nonpaddy farm operators

Independent Variable	Dependent Variable					
	LOWSHR	MIDSHR	FPSHR	CDSHR	TRANSHR	HEALSHR
Constant	101.4020	-61.5517	103.3570	-71.6540	25.5320	-13.7260
	(1.321)	(-1.590)	(1.306)	(-1.899)*	(1.609)	(-0.922)
LOGE	0.7401	10.5787	0.7277	12.3150	-3.5272	1.4230
	(0.072)	(2.040)*	(0.069)	(2.436)*	(-1.660)	(0.714)
N	0.4895	1.3718	-0.0182	1.5225	0.1468	0.0953
	(0.228)	(1.265)	(-0.008)	(1.441)	(0.331)	(0.229)
LANDPER	-24.8722	1.1439	-29.4487	0.1036	0.8412	3.8414
	(-2.798)*	(0.255)	(-3.211)*	(0.024)	(0.458)	(2.228)*
PNADULT	-41.4025	8.6569	-28.2521	7.1229	-8.7507	-2.4281
	(-2.836)*	(1.175)	(-1.876)*	(0.992)	(-2.900)*	(-0.858)
PCH_HH	56.4395	-6.5501	38.2988	-4.7834	3.4101	14.3090
	(3.005)*	(-0.691)	(1.977)*	(-0.518)	(0.878)	(3.929)*
AGEHH	0.3591	-0.1629	0.3916	-0.1617	-0.0607	0.0172
	(2.061)*	(-1.853)*	(2.179)*	(-1.887)*	(-1.686)	(0.509)
SEX	-15.8794	2.5937	-17.9383	1.1952	1.1364	2.1755
	(-2.228)*	(0.721)	(-2.440)*	(0.341)	(0.771)	(1.574)
ED	-2.9064	-7.2853	-6.0614	-8.0696	3.8468	0.3908
	(-0.553)	(-2.749)*	(-1.119)	(-3.124)*	(3.542)*	(0.384)
IRRIDUM	-17.4923	-2.0762	-19.2676	-3.8377	2.2671	1.5677
	(-2.377)*	(-0.559)	(-2.538)*	(-1.060)	(1.490)	(1.098)
CYCLE	4.9990	-18.9584	3.4686	-17.6800	-1.5862	0.4899
	(0.244)	(-1.836)*	(0.164)	(-1.757)	(-0.375)	(0.123)
CAR	-647.3590	484.8960	-649.4010	458.7600	49.1030	-4.3295
	(-4.082)*	(6.060)*	(-3.970)*	(5.883)*	(1.498)	(-0.141)
MOTORCYC	369.2950	248.9160	491.4390	264.5600	-5.9874	-144.9900
	(1.013)	(1.354)	(1.307)	(1.476)	(-0.079)	(-2.051)*
TDIS	2.1000	0.0706	2.0089	0.2959	-0.0567	-0.0413
	(1.968)*	(0.131)	(1.825)*	(0.564)	(-0.257)	(-0.200)

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: The HIGHSHR coefficients were not included in this table because the F-tests were not significant. The first stage of the two-stage, least-square regression is presented in Table 30. See Table 25 for definitions of the variables. The numbers in parentheses are t-ratios. The sample size of nonpaddy farm operators is 24.

*Significant at the 0.10 level (two-tailed test).

services, purchased food and personal items, and health care. Although nonadults effectively demand less purchased food and personal items, younger children appear to receive more purchased food than their older siblings. And more health care is obtained for younger children. Children of all ages in nonpaddy farm households have less demand for fee-charging transport services.

Among paddy farm households, older household heads tend to spend a smaller share of income on modern health care, perhaps relying more on traditional reme-

Table 30—Coefficients of ordinary least squares regressions for per capita income equations, by type of household

Independent Variable	Dependent Variable = LOGE			
	Paddy Farm Operator	Nonpaddy Farm Operator	Cultivation Laborer	Non-cultivator
Constant	6.5349 (51.364)*	7.2775 (53.918)*	6.8674 (72.438)*	7.1036 (13.151)*
N	-0.0322 (-4.728)*	-0.1378 (-8.489)*	-0.0915 (-11.035)*	-0.0445 (-1.275)
LANDPER	0.2832 (12.095)*	0.3545 (3.916)*	-0.0135 (-0.085)	-0.5957 (-0.487)
PNADULT	-0.3520 (-3.194)*	-0.2033 (-1.410)	0.1740 (1.611)*	-0.1044 (-0.262)
PCH_HH	0.0328 (0.737)	-0.2331 (-1.218)	-0.1090 (-2.438)*	-0.0695 (-0.359)
AGEHH	0.0011 (0.697)	-0.0072 (-3.768)*	0.0043 (3.321)*	-0.0062 (-0.993)
SEX	-0.0064 (-0.104)	0.2434 (3.659)*	-0.1363 (-3.350)*	0.0293 (-0.123)
ED	0.2135 (4.985)*	0.4125 (5.991)*	0.0178 (0.396)	0.1792 (0.944)
CYCLE	-0.3057 (-2.753)*	1.0268 (-8.551)*	-0.8773 (-8.520)*	-0.2365 (-0.560)
CAR	-1.9820 (-2.476)*	4.3682 (13.683)*	-2.1611 (-3.066)*	-6.2075 (-2.737)*
MOTORCYC	7.7901 (3.298)*	2.7104 (4.274)*	7.8893 (4.448)*	12.1753 (2.307)*
IRRIDUM	0.1268 (2.114)*	0.2918 (4.449)*	0.1401 (2.728)*	0.0714 (0.404)
TDIS	-0.0019 (-0.224)	-0.0051 (-0.526)	0.0236 (3.363)*	-0.0113 (-0.437)
LDIS	-0.0613 (-0.832)	-0.5049 (-7.947)*	0.0933 (1.593)*	-0.1082 (-0.696)
Adjusted R^2	0.544	0.972	0.666	0.354
F	38.682	176.520	40.565	3.756
Sample size	154	24	122	37

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: The numbers in parentheses are t-ratios. See Table 25 for a definitions of the variables.

*Significant at the 0.10 level (one-tailed test).

dies than households with younger heads. This pattern is not found among nonpaddy farm operators. Instead, older nonpaddy farm operators tend to spend a smaller share on middle-order goods and services and consumer durables but a larger share on low-order goods and services and purchased food and personal items. Day-to-day needs seem to be different for nonpaddy farmers—diversification of expenditures might be constrained by a need to meet food requirements through cash purchases.

Male nonpaddy farmers spend a smaller share on purchased food and personal items than do female heads. This does not hold true for paddy farmers. It may be that a female's concern for feeding the family is more apparent when the acquisition of food requires cash, as appears to be the case for nonpaddy farm households. Female household heads are, therefore, more likely to allocate cash to food and personal expenditures when consumption from their own production is not adequate.

Higher-educated nonpaddy farmers spend more on transportation relative to consumer durables and middle-order goods and services. The relative magnitudes of the coefficients suggest that the educated also shift consumption toward consumption from their own production, since the coefficient for transportation is smaller than the coefficient for consumer durables.

In the better-developed villages, nonpaddy farmers produce more for their own tables and spend a smaller share of income on low-order goods and services such as purchased food and personal items. Irrigation development seems to increase self-sufficiency at the household level for nonpaddy farmers. This is probably a spurious result since there is no reason for the quality of irrigation to affect the behavior of farmers who do not have access to irrigation, except through the effect of village irrigation on household income, which has already been estimated (see Table 30).

Paddy farmers in villages where bicycles are more accessible tend to spend a smaller share on low-order goods and services and consume more from own production than those in villages with a smaller proportion of bicycle-owning households. However, nonpaddy farm households spend a smaller share on middle-order goods and services, particularly consumer durables. Bicycles may increase production by allowing more inputs to be transported to food crops, resulting in more consumption from own production by paddy farm households. Production on the unirrigated nonpaddy farms may also benefit, but not to such an extent that purchases of food are affected.

In villages where automobiles are more accessible, nonpaddy farm households spend less on the locally accessible low-order goods and services (including purchased food and personal items) and spend more on middle-order goods and services (including consumer durables). In addition to extending the range of travel, cars provide extra carrying capacity. However, it is not known why automobile accessibility has no observed effect on paddy farm households.

It is also a mystery why greater accessibility to motorcycles and motorscooters should lead to a lower share of income being spent on health services (specifically, allopathic clinics) by nonpaddy farm households. Although these vehicles are not ideal for transporting someone who is ill, their availability should be irrelevant; instead there is a negative effect.

Why the expenditure patterns of paddy and nonpaddy farm households are influenced by the distance to the nearest bus stop is not puzzling, however. Where bus service is less accessible, people cannot travel easily to distant markets. Therefore, they select from among the locally available low-order goods and services (including purchased foods and personal items). As expected, when buses are less accessible, paddy farm households (but not nonpaddy farm households) spend a smaller share of their income on services in the high-order category and in the health category. The signs of the statistically significant variables are summarized in Table 31 for paddy and nonpaddy farm households.

Average and Marginal Budget Shares. Because paddy farm households consume more food from their own production than do other households, the average budget share for low-order goods is lower for paddy farm households than for any of the other household types (Table 32). Cultivation laborers spend a smaller share of total per capita expenditure on middle-order services, which include clothing and other consumer durables. All of the household types spend very little on high-order goods and services.

Paddy farm households also spend a smaller share of an incremental addition to per capita income on low-order goods and services than do nonpaddy farm households (Table 32). Thus, the trend will be for paddy farmers to continue to consume more from their own production. However, as paddy farm incomes increase, their demand for middle-order goods and services will expand at a faster rate than would be the case for nonpaddy farm households experiencing a similar increase in per capita income. Marginal budget shares are not calculated for cultivation laborers and noncultivators, because regression estimates were statistically significant for farm households only.

Expenditure share elasticities are calculated using the average and marginal budget shares. Most categories of cash expenditure are associated with elasticities of 1.0 or greater (Table 32). Higher incomes tend to shift consumption toward market purchases and away from consumption of own production. Thus, agricultural growth linkages are apparent for both paddy and nonpaddy farm households.

Marginal Expenditures and Elasticities with Respect to Distance. Given that the average total annual per capita expenditure for paddy farmers is Rs 752.90, the

Table 31—Signs for statistically significant regression coefficients for paddy and nonpaddy farm operators by service category

	Hierarchy Classification			Economic Classification			
Variable	LOWSHR	MIDSHR	HIGHSHR	FPSHR	CDSHR	TRANSHR	HEALSHR
Constant	. . .	. . .	. . .	. . .	- NP	. . .	. . .
LOGE	. . .	+ NP	. . .	. . .	+ NP	- NP	. . .
N	. . .	. . .	. . .	. . .	. . .	. . .	. . .
LANDPER	- NP	. . .	. . .	- NP	. . .	. . .	+ NP
PNADULT	- NP	. . .	. . .	- NP	. . .	- NP	. . .
PCH_HH	+ NP	. . .	. . .	+ NP	. . .	. . .	+ NP
AGEHH	+ NP	- NP	. . .	+ NP	- NP	- NP	- P
SEX	- NP	. . .	. . .	- NP	. . .	. . .	. . .
ED	. . .	- NP	. . .	. . .	- NP	+ NP	. . .
IRRIDUM	- NP	. . .	. . .	- NP	. . .	. . .	. . .
CYCLE	- P	- NP	. . .	. . .	- NP	. . .	. . .
CAR	- NP	+ NP	. . .	- NP	+ NP	. . .	. . .
MOTORCYC	. . .	. . .	. . .	. . .	. . .	. . .	- NP
TDIS	+ P, NP	. . .	- P	+ P, NP	. . .	. . .	- P

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: P = paddy farmers, NP = nonpaddy farmers. See Table 25 for definitions of the variables. There are 154 paddy farmers and 24 nonpaddy farmers in the sample.

Table 32—Average and marginal budget shares and elasticities, by type of household

Service Group	Average Budget Share				Marginal Budget Share		Elasticity	
	Paddy Farmer	Nonpaddy Farmer	Cultivation Laborer	Non-cultivator	Paddy Farmer	Nonpaddy Farmer	Paddy Farmer	Nonpaddy Farmer
Low order	56.15	83.17	88.56	87.68	52.90	86.12	0.942	1.035
Middle order	8.98	7.75	3.76	7.13	13.88	8.83	1.546	1.139
High order	0.31	0.00	0.25	0.43	1.24	1.47	4.000	1.110
Food and personal	52.86	79.79	87.25	85.57	53.45	83.64	1.011	1.048
Consumer durables	8.88	7.33	3.71	6.54	15.17	11.55	1.708	1.575
Transport	2.58	2.24	1.27	2.56	1.05	2.52	0.407	1.125
Health	1.12	1.58	0.37	6.57	2.95	3.31	2.634	2.095

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

following marginal expenditures with respect to distance are derived from negative and statistically significant budget-share regression coefficients: −0.73 for high-order goods and services and −0.81 for health (allopathic clinics). These figures represent the change in expenditure in rupees for a 1-kilometer increase in distance to the nearest bus stop. Given a mean distance of 2.82 kilometers to the nearest bus stop and per capita expenditures of Rs 2.33 on high-order services and Rs 8.43 on health, the percentage change in expenditure brought about by a 1 percent increase in distance is described by the following elasticities: −0.88 for high-order services and −0.27 for health.

For policy purposes, the marginal value is probably more relevant. Expansion of bus access to rural paddy farmers may not have much effect at the household level, since the average paddy farmer need not travel more than 3 kilometers to catch a bus, and only two extra rupees would be spent per person on high-order goods and services if bus service were brought into the village. However, the location of the consumer services to which people travel may be more important, as is suggested by the following analyses of producer services. (Unfortunately, the locations of consumer services were highly correlated with each other, and services were located at widely varying distances from the villages. Therefore, distances to specific consumer services could not be used, and no meaningful measure of mean distances to services could be derived. So, distance to bus service was the most useful proxy for access to services.)

Demand Regressions for Input Services

Dependent and Independent Variables. Regression models were also developed to help explain the effects of access (based on distance) to inputs on the patterns of purchases of fertilizer, seeds, and credit. Using data from the separate income and expenditure study of North Arcot, the dependent variables chosen were the values of fertilizers, seed, and credit bought by the household, the latter being the amount of credit received for farming purposes (including loans for farmland, livestock, machinery, and other agriculture-related purchases). These estimations of effective demand are based on total value of fertilizer, seeds, or credit purchased by a household in one year. Note that the credit demand only includes loans received and not loans applied for but not approved.

The independent variables are basically the same as those in budget share equations, except LOGE, CLDUM, and NPDUM are excluded, and TRAILER is added (Table 33). For the input equations, the distance variables are the distances in kilometers to the nearest fertilizer, seed, and credit service centers, rather than distance to the nearest bus stop.

Interpretation of Regression Results. From the estimated regression coefficients for paddy farms (Table 34), it is evident that the amount of land owned has a positive effect on fertilizer, seed, and credit demand, with statistically significant t-scores for the fertilizer and seed equations. The education level of the household head has a positive and statistically significant impact on demand for seed. For seeds and credit, the distance to the nearest service centers providing these inputs does not significantly affect the demand for them. But it does have a statistically significant effect on fertilizer demand—the distances to fertilizer and credit services have negative effects on fertilizer demand. The regression result shows that for a 1-kilometer increase in the distance to the nearest fertilizer shop, there will be a

Table 33—Description of key variables included in input and output regressions, by type of household

Variable	Description	Paddy Farm Operator	Nonpaddy Farm Operator
Dependent		(Rs)	
SEEDS	Value of HYV seeds purchased	75.93	25.24
FERTILIZ	Value of fertilizer purchased	76.82	10.18
CREDIT	Value of credit borrowed	623.76	161.00
GVPAG	Value of marketed crop production	1,770.51	72.86
Independent			
LANDOWN	Owned land (hectares)		
N	Household size		
SEX	Sex of head of household (male = 1, female = 0)		
ED	Education of household head (1 = above elementary)		
PNADULT	Nonadults as percent of household members		
PCH_HH	Young child as percent of household members		
AGEHH	Age of household head (years)		
SEEDDIS	Distance from village to nearest seed market (kilometers)		
FERTDIS	Distance from village to nearest fertilizer market (kilometers)		
CREDTDIS	Distance from village to nearest credit services (kilometers)		
OUTPDIS	Distance from village to neareast output market (kilometers)		
TRAILER	Percent of households in village owning tractor trailers		
CYCLE	Percent of households in village owning bicycles		
CAR	Percent of households in village owning cars		
MOTORCYC	Percent of households in village owning motorcycle/mopeds		
IRRIDUM	Better irrigated village (yes = 1, no = 0)		
PPDUM[a]	Farm type (paddy = 1, nonpaddy = 0)		

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

[a] Only used for sample including paddy and nonpaddy farms.

Rs 24.70 decline in the value of the fertilizer purchased (a 4.3 percent decline for a 1.0 percent increase in distance). And there will be a Rs 25.97 decline for a 1-kilometer increase in the distance to the nearest credit source. For modes of transport, an increase in the percentage of households owning bicycles in a village will have a positive and statistically significant effect on demands for fertilizer and credit, because bicycles help farmers to reach services and to transport inputs more easily. However, the coefficient for the car ownership variable in the fertilizer demand equations was inexplicably negative and statistically significant. Finally, owning a motorcycle increases the demand for seeds just as bicycle availability increases the demand for other inputs.

Nonpaddy farm regressions are not significant; results for the weighted aggregation of paddy and nonpaddy farms conform to the separate paddy farm results. Approximately three-quarters of the farms are paddy farms. The inclusion of a dummy variable in the regression model did not reveal any statistically significant differences between paddy and nonpaddy farms (see Appendix 2, Table 47).

Demand Regression for Output Marketing Services

Dependent and Independent Variables. One final regression model was estimated in order to identify the effect of access to agricultural marketing on revenue from marketed crops. The independent variables include those used in the input

Table 34—Ordinary least squares regression coefficients for input demand equations, paddy-farm operators

Independent Variable	Dependent Variable		
	Seeds	Fertilizers	Credit
Constant	151.380 (0.839)	-239.860 (-1.877)*	0.36884 (1.189)
N	-2.041 (-0.412)	4.390 (1.255)	-0.00165 (-0.196)
LANDOWN	9.847 (3.055)*	8.570 (3.769)*	0.00544 (0.986)
PNADULT	-23.217 (-0.246)	29.635 (0.445)	-0.18483 (-1.143)
PCH_HH	-45.954 (-0.402)	-6.810 (-0.084)	-0.04034 (-0.206)
AGEHH	-0.497 (-0.405)	1.230 (1.419)	-0.02310 (-0.105)
SEX	-8.717 (-0.148)	-22.575 (-0.542)	-0.15493 (-1.534)
ED	62.561 (2.048)*	32.264 (1.497)	0.02714 (0.519)
SEEDDIS	-16.440 (-0.990)	12.400 (1.059)	-0.03473 (-1.223)
FERTDIS	-24.809 (-1.390)	-24.700 (-1.962)*	0.00678 (0.222)
CREDTDIS	23.294 (1.519)	-25.974 (-2.401)*	-0.00579 (-0.221)
TRAILER	-457.278 (-0.487)	401.106 (0.606)	-0.46238 (-0.288)
CYCLE	69.062 (0.748)	134.352 (2.064)*	0.27237 (1.725)*
CAR	697.364 (0.439)	-2,064.799 (-1.841)*	-2.66704 (-0.981)
MOTORCYC	7,922.825 (2.084)*	-2,223.880 (-0.829)	1.27653 (0.196)
IRRIDUM	64.461 (0.753)	1.648 (0.027)	0.13734 (0.938)
Adjusted R^2	0.20552	0.17385	0.02966
F	3.6215	2.9498	1.3111

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: See Table 33 for definitions of the variables. The numbers in parentheses are t-ratios.

*Significant at the 0.10 level (one-tailed test).

demand equations, but the distance to the nearest output market replaces the other distances in the model (Table 33). The agricultural produce sold consisted of paddy and paddy straw, groundnuts and groundnut straw, ragi and ragi straw, and pulses and pulse straw.

Interpretation of Regression Results. For paddy farms the estimated regression coefficients are, as expected, positive and statistically significant for land owned and the percentage of households owning bicycles in the village, and the coefficient is negative and statistically significant for the distance to the nearest market center where farmers sell crops (Table 35).

As in the results of the input demand regressions, the output marketing regression shows that distance is an important factor influencing the revenue from the sale of crops. Thus, for a 1-kilometer increase in distance to the nearest output market, the revenue from marketed crops to the farmer is reduced by Rs 124.53, or 0.62 percent for a 1.00 percent increase in distance.

These results hold true for the weighted aggregation of paddy and nonpaddy farms. Land owned, distance to nearest market, and percentage of households owning bicycles remain statistically significant when nonpaddy farms are included (see Appendix 2, Table 48).

Household Patterns of Service Use and Regional Patterns of Distribution of Services

The foregoing analysis of household patterns of service use demonstrates the importance and significance of access to services in the determination of household use of these soft infrastructural services, whether consumer- or production-oriented. These findings, together with the analyses of regional and locational gaps, of the relationship between hard and soft infrastructural services, and of population thresholds of services presented in the previous chapter, could well form a useful basis for sound planning of the distribution system for production- and consump-

Table 35—Ordinary least squares regression coefficients for output market equation, paddy farm operators

Independent Variable	Marketed Output	
	Coefficient	t-Ratio
Constant	-3,816.50602	-1.182
N	66.71802	0.536
LANDOWN	336.33847	4.179*
PNADULT	671.11516	0.286
PCH_HH	1,774.05735	0.618
AGEHH	6.73866	0.222
SEX	115.26107	0.078
ED	538.09349	0.701
OUTPDIS	-124.52978	-2.449*
TRAILER	-10,865.84322	-0.499
CYCLE	4,225.46497	2.917*
CAR	-3,091.80798	-0.229
MOTORCYC	63,427.65031	0.741
IRRIDUM	2,514.55126	1.228
Adjusted R^2	0.24116	
F	3.22450	

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.
Note: See Table 33 for definitions of the variables.
*Significant at the 0.10 level (one-tailed test).

tion-oriented goods and services in the study region. Three examples taken from input marketing, output marketing, and health services illustrate this point.

Input Marketing. This example relates to fertilizer shops. The household-level analysis shows that the value of fertilizer purchased by a farmer would increase by Rs 24.70 if the shops providing fertilizer were 1 kilometer closer to the farmer's village. The regional findings presented in Table 13 indicate that the median population size at which these establishments appear in the regional settlement system is 5,340 persons. The regional results in Table 15 indicate that there are 4 settlements in the study region that have reached this median population threshold but do not have the service. It is therefore reasonable to recommend that investment in new fertilizer shops should be in these settlements. The regional findings in Table 9 show that in 7 of the 17 middle-order subregions that provide input services for the rural population, provision of these services is below average. Also, 1 of 7 high-order subregions has below-average provision of input services (Table 11). This suggests that new locational investment in fertilizer establishments should, as far as possible, be aimed at these 7 middle-order subregions or at Arni, the deficient high-order subregion. In selecting among the subregions for investment, however, the *least* poorly developed of the deficient subregions should be chosen first, in accordance with the efficiency approach discussed in Chapter 4, because this approach is the most cost-effective and least time-consuming way of reducing disparities in rural infrastructural development in the study region.

Output Marketing. It can be seen from the household-level analysis that revenue for the farmer from marketed crops would increase by Rs 124.53 if marketing establishments (such as market centers) were brought 1 kilometer closer to the farmer's village. The main crops grown in the study region are paddy and groundnuts. From regional findings summarized in Table 14, it is known that the median population size at which paddy marketing centers appear in the regional settlement system is 8,730 persons, and 8,890 persons for groundnut marketing centers. Table 15 indicates that 4 settlements in the study region have the median population thresholds but do not have one or the other of these marketing establishments. Moreover, 9 of the 17 middle-order subregions providing marketing services have below-average provision (Table 9), and 2 of the 7 high-order subregions have below-average provision (Table 11). Therefore, new locational investment in marketing establishments should be aimed at these subregions, again investing in the least poorly developed of the below-average subregions first.

Health Services. Using allopathic clinics as an example, the household-level analysis shows that expenditure on allopathic services would increase by Rs 0.82 if bus service were brought 1 kilometer closer to the household's village. The median population size at which an allopathic clinic appears in the regional settlement system is 3,470 persons (Table 14). There are 12 settlements in the study region that have the median population threshold but do not have the allopathic clinic (Table 15). Nine of the 17 middle-order subregions that provide health services have below-average provision (Table 9), and 1 of the 7 high-order subregions, Wandiwash, has below-average provision of health services (Table 11). Consequently, new locational investment in private hospitals should be aimed at some of these subregions. And, since 7 of these 9 middle-order subregions have below-average provision of transportation services as well, they might benefit from simultaneous improvement of bus service to hospitals, keeping in mind that it is most efficient to bring the least poorly developed regions up to standard first.

It is important, from the point of view of planning for the provision of these consumption and production services, that the suggested new locations not only be closer to the service-deficient regions, but also that most be located within these regions.

The Public and Private Sectors and Service Provision. These examples demonstrate how the results from household and regional analyses could be used to arrive at locational priorities for the development and improvement of distribution systems for goods and services. They also raise an important issue: the roles of the public and private sectors in this new investment. To facilitate the participation of the private sector in rural areas, the government would have to provide inputs such as land, electricity, water, and credit to potential entrepreneurs. This report shows that potential exists for improving the distribution systems of goods and services in the study region. This potential can be realized if both the public and private sectors work to fill in the subregional locational gaps through policy intervention and direct investment in the regional settlement system. (This aspect is discussed further in Chapter 6.) Hazell and Ramasamy (1991) have addressed the issue as follows:

> The rapid and geographically dispersed growth of the nonfarm economy suggests an elastic structure, which is of course essential if the agricultural growth multipliers are to realize their full potential. Government policy has been generally conducive to this pattern of growth. The government actively supports small businesses through an array of direct assistance programs. It has also invested heavily in basic infrastructure over the years, and there is now a well-developed transport, telecommunication, postal, banking, water, and electricity system throughout the region, as well as a legal and institutional setting that encourages the private sector. Government has also been active in providing a range of producer and consumer services itself, for example, foods and general provisions through ration shops, agricultural marketing, and bus and financial services. These activities compete directly with the private sector, and this may help to keep costs down. The government may also have played a lead role in providing these services in the more remote areas where provision by the private sector was less adequate.

Central Place Theory and Households in the Study Region

Central place theory has always recognized the importance of demand for central functions (services) as a basis for the emergence of central places (service centers). It also recognizes the importance of access to these central functions and the central places that provide them so that potential demand can be converted into actual demand. However, classical central place theory does not analyze the impact of access to central functions or the demand for them at the household level.

As this chapter has shown, when there is better access at the household level to central functions (services), there is greater demand for (expenditure on) them. Higher incomes from agriculture tend to shift household consumption—at least for farming households—toward market purchases and away from consumption of own production. In the study region, agriculture's linkages to nonagricultural sectors of the economy are apparent and are reflected in the emergence of new and the strengthening of old central places (service centers) which provide the central functions (services) demanded by the households.

It can also be argued that by incorporating these findings on the access-demand relationship into the analyses of centrality-deficient complementary regions (gaps in the subregions) and deficiencies in the central place structure of the study region (gaps in the settlement system), it should be possible to identify and to fill in these gaps in the provision of central functions. How to accomplish this is addressed in this chapter. In the next chapter, empirical evidence from the study region is used to examine how this process has evolved over time.

6

CHANGING PATTERNS OF SERVICE PROVISION AND USE AT THE REGIONAL AND HOUSEHOLD LEVELS

Comparison of Two Points in Time

As noted in Chapter 2, the 1982/83 field survey also collected data on the availability and use of services in the study region for the year 1973/74, based purely on recall. The universities of Cambridge and Madras had conducted their own survey of the study region in that year, and reference was made to that survey in the 1982/83 questionnaire. At the village level, less ambiguity was found in recalling whether a service was available than about the frequency of use of a service or the number of services available in a settlement. People were better able to remember where they went to avail themselves of a service. Thus, it was clear that the recall data on availability, patterns of use, and distance were somewhat more reliable than those on frequency of use and number of services.

In the following paragraphs an attempt is made to note the changes that have taken place in the patterns of provision and use of services in the study region at both the regional and the village levels, bearing in mind, of course, the above-noted difficulties in the recall of information.

Other changes were also taking place, particularly in the agricultural sector of the economy of the study region. Before noting the changes in the patterns of availability and use of services, therefore, these changes will be mentioned briefly in order to put the changes in rural service infrastructural development in their proper perspective.

Changes in the Agricultural Sector

The changes in the agricultural sector relate to farm size and technology adoption, farm size and yields, employment in agriculture, agricultural incomes, distribution of income and poverty, and regional impact of agricultural growth (Hazell and Ramasamy 1991).

- In 1973/74, only 15 percent of the small farmers had adopted HYV paddy, whereas among the large farmers the adoption rate was about 66 percent. In 1982/83, however, adoption of HYV paddy was more widespread; more than 90 percent of the paddy area was consistently planted with HYVs, with no systematic difference by farm-size group.
- There is a positive but statistically insignificant relationship between farm size and yields. Yields on small farms are not significantly different from the

yields obtained by the large farms. It appears, therefore, that the new agricultural technology has achieved "scale neutrality" in the study region.

- Between 1973/74 and 1983/84, there was a 70 percent increase in total adult employment per farm in paddy production, and a 44 percent increase per farm in all other crop production. Changes in employment were due to more intensive cultivation of land, particularly to larger gross areas allocated to paddy.
- In real value, family incomes doubled for large paddy farmers between 1973/74 and 1983/84. Small paddy farmers and landless laborers also doubled their incomes. Nonpaddy farmers and nonagricultural households did less well, increasing the real value of their incomes by about 50 percent over the same period of time.
- There were substantial absolute income gains for all households, and absolute poverty declined. The relative distribution of incomes of households improved in that the small paddy farmers and landless laborers gained relative to other groups.

  A number of factors are responsible for these favorable income changes: (1) since distribution of land did not become noticeably concentrated, there was less scope for concentration of incomes at the top end of the distribution; (2) agricultural employment increased significantly; (3) incomes per hectare were highest for small paddy farmers; (4) nonfarm sources of income and employment increased significantly; and (5) the state government provided more goods and services, such as credit, transport, health, education, communications, agricultural extension, fertilizer and seed distribution, agricultural marketing, electricity, employment, and subsidized food.
- In the region, each rupee increase of value added in agriculture stimulated an additional Rs 0.84 increase of value added in the nonfarm sector (Hazell and Ramasamy 1991). Half of this gain is due to agriculture's demand for inputs and for output marketing, as well as processing, and the other half is due to increased consumer demand as a consequence of increased incomes.

  The agrobusiness sector accounts for Rs 0.31 of this multiplier, the government accounts for another Rs 0.15, and the private sector, apart from agrobusiness, accounts for the remaining Rs 0.38. Thus, interindustry and demand linkages are quite important in the study region. In almost all cases of government intervention, the government is present as a matter of last resort and as a facilitator of development.

Changes in the Settlement System

Given the above changes in the agricultural sector of the rural economy, it should come as no surprise that there would be commensurate changes in the regional distribution of the shops and establishments that provide the goods and services. Since these shops are located in the settlement system of the study region, it is also not surprising that there would be commensurate changes in the regional settlement system. This analysis encompasses changes between 1973/74 and 1982/83 in the distribution of population among settlements, the distribution of service provision among settlements, the spatial features of middle-order service centers, and the index of service provision.

Distribution of Population in Settlements

Over the years 1973-83, the settlement system has become relatively less top heavy. The middle segment (settlements with populations of 2,500-9,999) has grown from about 25 percent of the total population to just above 30 percent. This strengthening of the middle segment also means that there are more locational choices for service provision in 1983 than there were in 1973 (Table 36).

In the context of the overall policy of development of rural service infrastructure followed by the state government through decentralization in the study region, it can be seen that the large urban centers in the study region have not been the sole recipients of public and private sector investment in rural service infrastructure. Small urban centers and large villages are also being chosen for such investment.

Distribution of Service Provision in Settlements

Service provision, compared with the distribution of population, has become even more balanced, with a remarkable increase in the percentage of services provided by the middle segment of the settlement system (service scores between 40.01 and 100.00), rising from about 25 percent in 1973 to just above 40 percent in 1983. The highest segment (with service scores of 130.01 and above) no longer dominates the study region. Thus, large towns and cities are not the only major providers of services; many small towns and larger villages are assuming that role, having emerged as service centers during 1973-83 (Table 37).

Spatial Features of Service Centers

During the years 1973-83, the number of service centers in the study region increased from a mere 75 to 473 at the low order of the service hierarchy (out of a total of 535 settlements). The number of middle-order service centers rose from 16 to 22, but the high-order centers did not increase at all. Given that just over three-fourths of middle-order service centers and just under two-thirds of high-order service centers are from within the study region, it is clear that the centers within the study region most significantly influence the patterns of provision of

Table 36—Distribution of settlements by population size group, 1971 and 1981

	1971			1981		
Population	Number of Settlements	Total Population	Percent of Population	Number of Settlements	Total Population	Percent of Population
Less than 1,000	58	52,085	4.73	3	2,584	0.21
1,000 - 2,499	399	611,141	55.49	422	640,908	51.77
2,500 - 4,999	58	193,201	17.54	87	277,589	22.42
5,000 - 9,999	14	93,695	8.51	15	99,021	8.00
10,000 or more	6	151,146	13.73	8	217,851	17.60
Total	535	1,101,268	100.00	535	1,237,953	100.00

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Table 37—Scores of service provision and distribution of settlements, 1973 and 1983

Year/Score	Number of Settlements	Percentage of Settlements	Total Score	Percentage of Total Score
1973				
Less than 10.00	1	0.19	7.14	0.03
10.00 - 40.00	420	78.50	12,490.42	59.75
40.01 - 70.00	89	16.64	4,204.35	20.11
70.01 - 100.00	15	2.80	1,216.98	5.82
100.01 - 130.00	2	0.37	212.76	1.02
130.01 or more	8	1.50	2,774.72	13.27
Total	535	100.00	20,906.37	100.00
1983				
Less than 10.00	0	0.00	0.00	0.00
10.00 - 40.00	334	62.43	10,686.95	46.52
40.01 - 70.00	169	31.59	7,970.84	34.69
70.01 - 100.00	15	2.80	1,230.24	5.35
100.01 - 130.00	9	1.68	1,085.68	4.73
130.01 or more	8	1.50	2,000.80	8.71
Total	535	100.00	22,974.51	100.00

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

services in the study region. The changes in the number of service centers at the middle-order level, together with their spatial features, best reflect the changes in the regional distribution system of services for the study region.

As noted above, the 16 middle-order service centers in 1973 increased to 22 by 1983. Of the original 16, 2, namely Tindivanam and Vellore, had become high-order service centers, which means that 8 new middle-order centers emerged during the period. With the emergence of these new centers and the strengthening of the old centers, it is expected that the average area covered by a service center would decline (Table 38). The number of villages served by each center would also decline, but the population served by each center could either increase or decrease depending upon the base from which the population grew during 1973-83.

This is what seems to have happened. Of the 14 centers for which comparison can be made, Chetpet, Nemili, and Kaveripakkam gained in service area, but the rest either remained constant or declined. Only Kaveripakkam gained in the number of villages served; the rest remained either the same or declined. Some have gained and others lost service population, with those losing being the more important and older centers—Arkonam, Arni, Tiruvannamalai, Wandiwash, and Thiruvathipuram (Cheyyar). The declining size of the service areas indicates that distances to the service centers themselves have also declined, making them more accessible to the rural population. This is in agreement with earlier findings that both population and service provision are becoming less top heavy with the emergence of new centers, which cut into the service areas and populations of the existing centers.

Index of Service Provision

The index of service provision is calculated for the entire study region and not for its individual subregions. This is a spatial index in that it first measures the

Table 38—Spatial features of middle-order service centers, 1973 and 1983

Service Center and Subregion	1973			1983		
	Service Area	Service Population	Settlements Served	Service Area	Service Population	Settlements Served
	(square kilometers)			(square kilometers)		
Arkonam	316.23	111,953	48	201.87	108,085	33
Arni	505.79	183,251	70	420.18	154,661	59
Chetpet	85.23	31,134	17	87.37	35,226	17
Desur	...	...	...	6.59	4,301	1
Kalasapakkam	...	...	...	2.08	2,443	1
Kancheepuram[a]	...	...	...	140.78	40,599	21
Kannamangalam	...	...	...	9.98	5,026	...
Kaveripakkam	21.08	9,732	3	32.68	14,141	5
Kilpennathur	...	...	...	24.66	10,471	2
Nemili	12.28	5,279	3	14.77	6,498	3
Peranamallur	...	...	...	14.96	4,256	1
Panapakkam	...	...	...	9.94	8,748	2
Polur	232.59	77,961	44	192.86	79,585	37
Solingar[a]	49.58	11,849	8	42.73	12,846	7
Thellar	...	...	...	14.70	6,513	1
Thiruvathipuram (Cheyyar)	198.46	67,046	38	194.09	71,806	37
Tindivanam[a]	2.93	1,130	1	...	...	...
Tirukovilur[a]	2.89	1,265	1	2.89	1,482	1
Tirutani[a]	34.32	10,301	4	34.32	12,376	4
Tiruvannamalai	616.45	222,202	104	431.02	192,970	81
Uthramerur[a]	6.25	1,069	1	6.25	1,061	1
Vellore[a]	55.12	26,882	8	...	...	...
Vettavalam	...	...	...	23.46	12,121	3
Wandiwash	396.32	118,144	66	290.67	91,150	47

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Note: Information about the service centers outside the study region is incomplete.

[a] These service centers are outside the study region.

provision of services per square kilometer. The percent change in this index over 1973-83 is calculated with 1973 scores as a base. As shown in Table 39, the level of total service provision has gone up. Considered individually, all services have shown a positive change, except banking, which has remained constant. Further, when the entire service provision is categorized as public or private sector, the values are marginally better for the public sector, but both show a steady improvement in service provision over the period.

The role of both the government and the private sector in providing these services seems to be equally important, given that the values in Table 39 are almost the same. In that table, the private sector is assumed to provide only retail services and the government sector is assumed to provide the rest of the services. In 1973, this was broadly the case. Since then, the private sector has moved rapidly to provide other services. What the table conceals is the extent of involvement of the private sector in provision of all services except the communication services in 1983.

Other studies have shown that the relative importance of the roles of government and private sectors in providing these services depends upon and varies with

Table 39—Index of service provision, 1973 and 1983

	Index of Service Provision[a]		
Service	1973	1983	Change
	(score/square kilometer)		(percent)
All services	7.56	8.44	11.64
Education	0.38	0.39	2.63
Health	0.14	0.16	14.28
Communication	0.52	0.64	23.07
Banking	0.08	0.08	0.00
Transportation	0.14	0.16	14.28
Agricultural inputs and implements	1.32	1.71	29.54
Animal husbandry	0.03	0.06	100.00
Marketing	0.87	0.90	3.44
Retail	4.08	4.34	6.37
Public sector	2.20	2.46	11.81
Private sector	5.36	5.99	11.75

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

[a] The index is the mean score per square kilometer for the study area.

the stage of agricultural development in that rural region (Wanmali 1983b). In an earlier stage of development, the government plays a leading role; in an intermediate stage, both government and the private sector are equally important; and in a later stage, the private sector plays a leading role.

Similarly, in the earlier stage, the government not only makes policy but also executes it, with the help of its own institutions; at an intermediate stage, its involvement in execution is greatly reduced by the entry of the private sector; and in the later stage, the government only formulates policy, leaving its execution entirely to the private sector.

The study region has been at the intermediate stage since 1973, when the new agricultural technology of improved seeds, chemical inputs, and irrigation was introduced. It now appears to be entering the later stage of agricultural development, where the role of government is to formulate policies to facilitate agricultural and rural development.

Changes at the Regional Level

It should be noted that the figures in Table 39 indicate the change in the densities of provision of services and not their volume of business. Thus, for example, when banking shows no change, it means that between the two points in time, for the study region as a whole, the density of banking services has remained constant. This does not take into account the volume of loans made available by the institutional banking sources and the services provided by the noninstitutional banking sources, both of which appear to have grown.

On the basis of the evidence presented so far in this and other chapters, it is clear that the growth of the study region's economy was a consequence of the technology-induced development of agriculture, which was responsible for increases in incomes in the farm and nonfarm sectors of the rural economy. Compared with the mid-1970s, this development in agriculture was facilitated by the greater availability of rural infrastructural services, which was itself also stimulated by the higher demand for services. Further, as agriculture prospered, incomes from it were spent on increasingly diversified but mostly locally produced and distributed goods and services, which, in turn, augmented the patterns of regional income and employment and strengthened the regional settlement and service systems. It appears that such multiplier effects are indeed a part of the basis of growth of the region's economy.

Unmistakably, the evidence also points to a process of decentralization of urban functions into the rural areas, where the emergence of new service centers at all levels of the service hierarchy has been fairly widespread in response to the demand for these functions from the households of the study region.

The central place theory has always recognized the importance of the existence of and increases in demand for central functions (goods and services) in the process of emergence and growth of central places (service centers). But being deductive in nature, the theory never provided any proof of this process, except to mention that population increases in settlements (as a proxy for household demand increases) will result in emergence and growth of central places.

What the present study has been able to demonstrate, not only on the basis of analysis of population at the settlement level, but also and more importantly on the basis of analysis of expenditure patterns at the household level, is how these increases in population and household demand influence the emergence and growth of nonfarm employment through and in the shops and establishments selling goods and services throughout the region. This gives rise to the establishment of new service centers and strengthening of old service centers. This inductive analysis of the emergence and growth of a central place system in the study region represents the unique methodological contribution of this study.

7

CONCLUSIONS AND POLICY IMPLICATIONS

Settlement Systems

Analyzing the settlement system within the framework of Christaller's ([1933] 1966) central place theory, modified by earlier studies in India (Wanmali 1970, 1983a, 1985; Sen et al. 1971) has enriched understanding of the demographic, functional, and spatial characteristics of North Arcot's regional settlement system and its provision and use of services. Demographically and functionally, the settlement system has become less "city" dominated during the years 1973-83. Goods and services have become more widely available in large villages and small towns, not in its major urban center alone. Spatially, there has been an increase in the number of service centers, most markedly at the low end of service provision, but also at the middle and high levels.

Most of the principles of central place theory are upheld in the settlement system of the study region (Christaller [1933] 1966). There is a hierarchy of services that underlies the hierarchy of settlements, and the high-order service centers provide more complex services to a greater number of people who live in a more extensive region than do the low-order service centers. However, no hexagonal service areas were encountered. Service areas were of all shapes and sizes and were mostly governed by local topography, such as rivers, forests, and hills, and by the existing transportation networks. The influences of the three principles of spatial organization of settlements—marketing, transport, and administration—were mixed. Marketing and transport principles were influential at the low level of the service hierarchy and all three principles at the middle and high levels.

In analyzing service provision within and between the subregions of the study region, it was possible to identify those services and subregions that have above- and below-average service provision. Those with below-average service provision were considered to have gaps in their service structure. This identification of gaps in the regional service provision was extended to settlements themselves by indicating those settlements that have the necessary threshold population to sustain a service but do not have the service. Along with the analysis of service provision at the subregional level, this analysis of population thresholds of services applies and extends research on the central place theory for developing countries.

The regional analysis was also helpful in identifying the effects of the availability of hard infrastructure, such as roads and road networks, on the development of soft infrastructural services, such as education, health, communication, banking, agricultural inputs, animal husbandry, agricultural marketing, and retail services. Where hard infrastructure was lacking, the probability of soft infrastructural services being available in a settlement declined.

The household-level analysis of effects of access to goods and services and modes of transport on expenditure patterns and budget shares is unique among the geographical analyses conducted on demand for services in general and on the growth and emergence of central places in particular. It also adds to the understanding of dynamics of distribution systems for goods and services in rural India.

Planning for the Provision of Rural Service Infrastructure

The results of the analyses help in identifying imbalances in the provision of services among the subregions in the study region. These, together with the results of the household analysis of the impact of access on expenditure, can help the development administrator set priorities for the provision of these services. An example of how this could be achieved is given below.

The budgetary allocations for the development of these services and similar allocations for special development projects are known for the study region.[20] These resources are made available by the government to local development administrators at both the district and the *panchayat union* level for investment in the rural areas. The time horizon for spending them is five years in India. When the results of the regional and household level analyses and the pattern of budgetary allocation are put together, a list can be drawn up of locational priorities for the provision of rural service infrastructure. For example, if resources are available for the provision of one marketing center for agricultural output over a period of five years, then, based on the results of the study, the settlements capable of supporting this service are known. One of the settlements in the least poorly developed subregions should be chosen for the center. When additional resources are available to the development administrators, they can continue to choose from the settlements on the list of priority locations. Thus, this list can provide a spatial basis for the planning of services until all the identified locational service gaps in the regional settlement system are filled.

Household Use of Services

In considering the conclusions drawn from the analysis of household use of services, one must keep in mind the major qualification that this report includes no information on prices of goods and services, nor does it analyze prices of inputs and outputs because these prices are administered by the government.

What becomes apparent from the household-level analysis is the potential for improving the design of the distribution system for goods and services. Some services demanded by households appear to be negatively and significantly influenced by a lack of access to bus service. Bus stops, accordingly, need to be brought nearer to consumers to realize the potential of household demand linkages. Some input and output marketing services demanded by the households were found to be negatively influenced by lack of access to them, suggesting that these services should be brought nearer to consumers. The gaps in the provision of these services are indicated, as well as the effects of lack of access to services on patterns of expenditure. The study demonstrates that, when available and accessible, these services help improve the total production and the productivity of agriculture and also help strengthen the linkages to nonagricultural sectors of the rural economy. The influence of factors such as ease of access to various modes of transport, which help conquer distance, is also estimated in household demand for various goods and services. Policies that influence direct access to these modes of transport (such as liberal credit for purchase of the modes of transport, cooperative ownership of certain modes, and so forth) should be devised and implemented. Thus, the results of the study could be useful in developing policies for improving the distribution system for those services and for tapping the potential market for them.

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[20] The budgetary allocations for government expenditure on current account and special projects are given in Appendix 2, Table 49.

Generalizing and Applying the Results

Because it is based on central place theory, it can be argued that certain elements of this study would be common even if it were conducted elsewhere in India or in other parts of the Third World: settlements, service availability, service use, population of settlements, and area of settlements. These elements are amenable to analysis of the type noted in Chapters 4, 5, and 6. Of course, the details will vary with the geographical contexts, but the framework of analysis will remain almost the same.

Therefore, it can also be argued that the policy implications emanating from such studies will be similar, although differences in geographical contexts are likely to influence them differently. For example, settlements of smaller population sizes and densities in southern Africa would result in a similar policy implication about the effects of access on demand for consumption and production goods and services, but perhaps the manner of providing services in that part of the Third World would be different. For example, in southern Africa, locations of services might be more mobile than fixed as in southern India, because of the high per capita cost of providing them in regions of low population densities. Above all, results specific to a region are necessary for policymakers in Third World countries, because the gaps, the thresholds of services,-and the estimates of effects of access on expenditure patterns, and through these, the linkage effects to the rest of the economy, will vary from country to country and from region to region.

The Development of the Regional Economy

The analysis also indicates that new agricultural technology, rural service infrastructure, and rural institutions appear to go hand in hand in reducing the polarization effects that were feared in the rural areas of the study region following the introduction of the new agricultural technology (Farmer 1977). From the beginning, the state government actively supported the establishment of rural institutions such as *panchayat unions* below the district level, as well as plans for the diffusion and decentralization of public-sector rural service infrastructure in the study region. This resulted in greater and better access to goods and services over a period of time and widespread decentralization of urban functions to the rural areas. This institutional and infrastructural development has enhanced the household and regional linkage effects for the rural population in a variety of ways, thereby improving the quality of rural life in the study region.

APPENDIX 1: REDUCED-FORM DETERMINANTS OF HOUSEHOLD EXPENDITURES

The results of an estimated reduced-form model are presented to substantiate the findings derived from the two-stage least-squares model estimated for the main text. Because, in the second stage, expenditure shares are estimated as a function of the natural log of total expenditure and the variables that determine the natural log of total expenditure, multicolinearity is likely to be a problem. Multicolinearity could affect the accuracy of parameter estimates. Although the reduced-form model does not allow for the separate examination of the effects of income level and the direct influences of household and village factors on expenditure behavior, the final impact of each factor may be more accurately estimated.

Household and village characteristics are expected to determine a household's level of income and to influence expenditure patterns. The household characteristics include the following variables:

Size of household (N),
Per capita land owned by household (LANDPER),
Nonadults as a percent of household members (PNADULT),
Young children as a percent of household members (PCH_HH),
Age of household head (AGEHH),
Sex of household head (SEX),
Education of household head (ED),
Paddy farm operator household (PPDUM),
Nonpaddy farm operator household (NPDUM),
Cultivation laborer household (CLDUM), and
Noncultivator household (NCDUM).

The village characteristics include the following variables:

Quality of village's irrigation capacity (IRRIDUM),
Bicycle-owning percent of village's households (CYCLE),
Car-owning percent of village's households (CAR),
Motorcycle or moped-owning percent of village's households (MOTORCYC),
Distance from village to nearest bus stop (TDIS), and
Distance from village to nearest center for low-order services (LDIS).

The estimated coefficient for each variable includes the indirect effect on expenditure behavior through the variable's influence on income level, as well as the direct effect on expenditure behavior. The direct and indirect effects can be in opposite directions—the coefficient captures the net effect.

The reduced-form model was estimated for a weighted sample of all household types and separately for each type. The results for paddy farm operators are presented in Table 40, nonpaddy farm operators in Table 41, cultivation laborers in Table 42, and noncultivators in Table 43. The results for the weighted sample of all household types are given in Table 44.

Table 40—Ordinary least squares regression results for budget shares of paddy farm operator households

Independent Variable	Dependent Variable						
	LOWSHR	MIDSHR	HIGHSHR	FPSHR	CDSHR	TRANSHR	HEALSHR
Constant	94.179	6.400	-1.103	89.149	5.936	2.773	0.022
	(10.253)*	(0.933)	(-0.994)	(9.754)*	(0.854)	(2.201)*	(2.449)*
N	-0.867	0.305	0.070	-0.899	0.336	-0.043	0.001
	(-1.910)*	(0.901)	(1.279)	(-1.991)*	(0.980)	(-0.701)	(2.601)*
LANDPER	-6.239	1.437	0.518	-6.760	1.674	0.224	0.005
	(-3.845)*	(1.187)	(2.640)*	(-4.187)*	(1.363)	(1.008)	(2.923)*
PNADULT	0.436	-10.534	-0.834	-0.075	-11.242	-0.201	0.004
	(0.051)	(-1.639)	(-0.801)	(-0.009)	(-1.726)*	(-0.171)	(0.471)
PCH_HH	10.005	15.997	9.285	7.605	21.926	-1.285	0.095
	(0.181)*	(0.387)	(1.388)	(0.138)	(0.524)	(-0.169)	(1.603)
AGEHH	0.003	-0.023	-0.012	0.016	-0.029	0.010	-0.000
	(0.033)	(-0.267)	(-0.885)	(0.141)	(-0.327)	(0.676)	(-2.705)*
SEX	-0.445	2.279	0.798	0.172	2.941	-0.935	0.002
	(-0.083)	(0.568)	(1.229)	(0.032)	(0.723)	(-1.269)	(0.482)
ED	-3.811	3.158	-0.369	-4.687	2.597	1.576	-0.003
	(-1.289)	(1.431)	(-1.034)	(-1.593)	(1.161)	(3.885)*	(-1.119)
IRRIDUM	-4.806	0.880	0.241	-4.191	0.892	-0.625	-0.005
	(-1.342)	(0.329)	(0.558)	(-1.176)	(0.329)	(-1.273)	(-1.060)
CYCLE	-52.940	2.324	1.220	-49.402	2.398	-1.024	-0.026
	(-7.854)*	(0.462)	(1.497)	(-7.366)*	(0.470)	(-1.108)	(-2.989)*
CAR	69.984	-20.590	7.958	47.118	-12.101	8.393	0.692
	(1.476)	(-0.582)	(1.389)	(0.999)	(-0.337)	(1.291)	(3.906)*
MOTORCYC	97.348	-45.403	-6.802	137.667	-41.570	-26.198	-1.954
	(0.735)	(-0.459)	(-0.425)	(1.045)	(-0.415)	(-1.442)	(-3.731)*
TDIS	2.365	-0.457	-0.112	2.249	-0.521	0.134	-0.001
	(3.303)*	(-0.856)	(-4.301)*	(3.157)*	(-0.963)	(1.366)	(-1.789)*
LDIS	-0.275	4.285	-0.318	-1.185	3.442	1.964	-0.016
	(-0.072)	(1.499)	(-0.688)	(-0.311)	(1.188)	(3.739)*	(-2.870)*
Adjusted R^2	0.34299	0.02967	0.02956	0.33678	0.01821	0.22204	0.24449
F	7.14396	1.35988	1.35852	6.97629	1.21833	4.35901	4.53650

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: The sample size of paddy farm operators is 154. The numbers in parenthese are t-ratios. The variables are defined in Table 25.

*Significant at the 0.10 level (two-tailed test).

Net Effects of Household Characteristics

Household Size

Larger households tend to allocate a greater part of the household budget to middle-order and high-order services at the expense of low-order services. The findings with regard to the increase is statistically significant for the weighted

Table 41—Ordinary least squares regression results for budget shares of nonpaddy farm operator households

Independent Variable	Dependent Variable					
	LOWSHR	MIDSHR	FPSHR	CDSHR	TRANSHR	HEALSHR
Constant	112.942	11.181	114.500	13.758	0.261	-0.118
	(5.468)*	(1.277)	(5.569)*	(1.654)	(0.070)	(-2.118)*
N	1.091	-0.135	0.221	-0.213	0.704	0.004
	(0.470)	(-0.138)	(0.096)	(-0.228)	(1.684)	(1.323)
LANDPER	-28.112	3.838	-32.342	2.985	0.116	0.052
	(-1.886)*	(0.607)	(-2.180)*	(0.497)	(0.043)	(2.513)*
PNADULT	-39.942	6.092	-25.205	4.272	-7.856	-0.032
	(-1.553)	(0.559)	(-0.984)	(0.412)	(-1.695)	(-0.949)
PCH_HH	156.148	-26.684	71.805	-25.019	15.347	0.796
	(1.161)	(-0.468)	(0.536)	(-0.462)	(0.633)	(4.393)*
AGEHH	0.293	-0.178	0.333	-0.186	-0.046	0.001
	(1.066)	(-1.528)	(1.215)	(-1.684)	(-0.940)	(1.427)
SEX	-17.010	6.025	-18.580	5.159	-0.128	0.016
	(-1.664)	(1.390)	(-1.826)*	(1.253)	(-0.070)	(1.190)
ED	-2.499	-2.767	-4.856	-2.867	2.581	0.023
	(-0.249)	(-0.649)	(-0.485)	(-0.708)	(1.425)	(1.264)
IRRIDUM	-20.222	2.152	-21.457	0.825	1.095	0.038
	(-1.942)*	(0.487)	(-2.070)*	(0.197)	(0.584)	(2.044)*
CYCLE	-1.921	-26.709	-2.733	-27.560	2.449	0.095
	(-0.099)	(-3.243)*	(-0.141)	(-3.522)*	(0.700)	(1.358)
CAR	-688.864	652.392	-690.215	649.361	-1.592	-1.684
	(-4.303)*	(9.611)*	(-4.332)*	(10.070)*	(-0.055)	(-1.525)
MOTORCYC	521.721	327.714	619.410	373.476	-58.106	4.133
	(1.138)	(1.686)	(1.358)	(2.023)*	(-0.704)	(1.342)
TDIS	2.915	-0.358	2.711	-0.126	0.005	-0.004
	(1.684)	(-0.489)	(1.574)	(-0.181)	(0.017)	(-1.328)
LDIS	-0.621	-5.362	-0.856	-6.258	1.731	0.008
	(-0.070)	(-1.418)	(-0.096)	(-1.942)*	(1.078)	(0.636)
Adjusted R^2	0.65236	0.8938	0.64275	0.90319	0.31719	0.50698
F	4.31997	15.88960	4.18319	17.50538	1.82188	2.68938

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: The sample size of nonpaddy farm operators is 24. High-order regressions were not included in this table because the F-tests were not significant. The numbers in parenthese are t-ratios. The variables are defined in Table 25.

*Significant at the 0.10 level (two-tailed test).

sample of all household types; the decrease is statistically significant for the sample of paddy farm operators. For the paddy-farmer sample, the noncultivator sample, and the weighted sample, larger households spend higher portions of their total expenditures on health services (represented by allopathic clinics). The results from the weighted sample indicate that larger households also expend a greater

Table 42—Ordinary least squares regression results for budget shares of cultivation laborer households

Independent Variable	Dependent Variable						
	LOWSHR	MIDSHR	HIGHSHR	FPSHR	CDSHR	TRANSHR	HEALSHR
Constant	97.847 (15.270)*	3.058 (0.967)	1.636 (1.330)	96.369 (14.734)*	5.194 (1.360)	0.628 (0.811)	0.010 (1.892)*
N	0.272 (0.416)	0.241 (0.746)	0.026 (0.214)	0.307 (0.460)	0.251 (0.643)	-0.026 (-0.334)	0.000 (0.244)
LANDPER	0.754 (0.076)	-4.749 (-0.969)	-0.709 (-0.372)	0.750 (0.074)	-6.015 (-1.016)	-0.541 (-0.451)	0.014 (1.907)*
PNADULT	-6.207 (-0.798)	2.458 (0.641)	0.507 (0.340)	-4.507 (-0.568)	2.339 (0.505)	-0.992 (-1.056)	-0.005 (-0.827)
PCH_HH	34.216 (0.867)	-18.478 (-0.949)	-7.413 (-0.979)	36.017 (0.895)	-28.049 (-1.193)	1.748 (0.366)	0.002 (0.065)
AGEHH	-0.110 (-1.111)	-0.001 (-0.033)	0.001 (0.076)	-0.078 (-0.774)	-0.008 (-0.144)	-0.018 (-1.560)	-0.000 (-1.177)
SEX	4.139 (1.299)	0.719 (0.458)	0.171 (0.281)	3.234 (0.994)	1.034 (0.545)	0.496 (1.289)	0.004 (1.783)*
ED	-1.280 (-0.409)	1.366 (0.885)	-0.319 (-0.532)	-2.072 (-0.649)	1.332 (0.714)	0.561 (1.484)	-0.003 (-1.235)
IRRIDUM	-1.407 (-0.456)	-0.275 (-0.181)	-1.012 (-1.708)*	-2.455 (-0.780)	-1.212 (-0.659)	0.543 (1.457)	0.001 (0.279)
CYCLE	-4.789 (-0.784)	-2.745 (-0.911)	-2.527 (-2.153)*	-5.996 (-0.961)	-5.383 (-1.477)	1.643 (2.224)*	-0.011 (-1.966)*
CAR	0.655 (0.015)	-15.280 (-0.687)	9.273 (1.072)	6.785 (0.148)	-3.234 (-0.120)	-5.702 (-1.047)	0.065 (0.645)
MOTORCYC	-277.761 (-2.770)*	41.413 (0.837)	15.362 (0.798)	-267.922 (-2.618)*	49.931 (0.835)	-11.266 (-0.929)	-0.248 (-0.848)
TDIS	-0.080 (-0.137)	-0.052 (-0.179)	0.130 (1.156)	0.050 (0.084)	0.078 (0.223)	-0.105 (-1.478)	0.000 (0.263)
LDIS	-11.582 (-3.666)*	4.868 (3.123)*	-0.376 (-0.620)	-13.358 (-4.142)*	2.809 (1.491)	3.298 (8.634)*	-0.001 (-0.281)
Adjusted R^2	0.18752	0.10999	0.03486	0.21121	0.02007	0.5164	0.06127
F	3.14816	2.15030	0.68647	3.49200	1.19100	10.93900	1.56400

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: The numbers in parenthese are t-ratios. The variables are defined in Table 25.

*Significant at the 0.10 level (two-tailed test).

share on consumer durables (including clothing and cloth). The paddy-farm households reduce the share allotted to food and personal services.

Larger households are expected to contain more members who can engage in income-generating work. This should allow the household to have a higher per capita level of expenditure. At higher expenditure levels, it is expected that consumption shifts in favor of the more cosmopolitan services represented by the

Table 43—Ordinary least squares regression results for budget shares of noncultivator households

Independent Variable	Dependent Variable						
	LOWSHR	MIDSHR	HIGHSHR	FPSHR	CDSHR	TRANSHR	HEALSHR
Constant	101.565 (16.120)*	3.932 (0.938)	0.900 (0.797)	98.603 (15.156)*	5.221 (1.162)	2.104 (2.333)*	0.009 (1.450)
N	−0.666 (−1.492)	−0.083 (−0.280)	−0.016 (−0.204)	−0.748 (−1.621)	−0.084 (−0.266)	0.030 (0.472)	0.001 (1.896)*
LANDPER	−10.544 (−3.155)*	3.191 (1.435)	3.132 (5.228)*	−11.695 (−3.389)*	5.390 (2.261)*	0.517 (1.083)	0.014 (4.930)*
PNADULT	−5.425 (−0.781)	2.939 (0.636)	0.290 (0.233)	−2.072 (−0.289)	2.739 (0.553)	−2.782 (−2.798)*	−0.008 (−1.370)
PCH_HH	28.546 (0.742)	−18.892 (−0.738)	−1.606 (−0.233)	28.260 (0.711)	−22.463 (−0.818)	1.352 (0.245)	0.027 (0.864)
AGEHH	−0.130 (−1.413)	−0.017 (−0.280)	0.006 (0.382)	−0.064 (−0.681)	−0.015 (−0.241)	−0.051 (−3.890)*	−0.000 (−1.625)
SEX	2.872 (0.936)	2.181 (1.068)	0.210 (0.382)	1.877 (0.592)	2.420 (1.105)	0.677 (1.541)	0.004 (1.396)
ED	−0.850 (−0.300)	0.332 (0.176)	−0.492 (−0.969)	−2.328 (−0.795)	0.022 (0.011)	1.280 (3.156)*	−0.000 (−0.158)
CYCLE	0.951 (0.149)	−2.764 (−0.650)	−1.439 (−1.257)	0.138 (0.021)	−4.570 (−1.003)	1.833 (2.005)*	−0.010 (−1.433)
CAR	−80.562 (−2.193)*	−0.127 (−0.005)	−0.189 (−0.029)	−73.846 (−1.947)*	4.083 (0.156)	−8.861 (−1.685)*	−0.008 (−0.061)
MOTORCYC	−380.152 (−3.625)*	60.851 (0.872)	17.397 (0.925)	−375.927 (−3.472)*	70.988 (0.949)	−4.336 (−0.289)	0.038 (0.108)
IRRIDUM	0.085 (0.027)	−0.650 (−0.312)	−1.275 (−2.271)*	−1.492 (−0.461)	−1.868 (−0.836)	0.972 (2.167)*	0.004 (0.993)
TDIS	−0.385 (−0.599)	−0.026 (−0.061)	0.139 (1.212)	−0.217 (−0.328)	0.121 (0.265)	−0.154 (−1.673)	0.000 (0.002)
LDIS	−10.294 (−3.116)*	4.838 (2.201)*	−0.113 (−0.192)	−11.939 (−3.500)*	3.049 (1.294)	3.145 (6.651)*	0.000 (0.122)
Adjusted R^2	0.40532	0.01395	0.12872	0.41492	0.01839	0.41543	0.27294
F	9.28391	1.17194	2.79556	9.61920	1.22768	9.63720	5.23660

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: The numbers in parenthese are t-ratios. The variables are defined in Table 25.

*Significant at the 0.10 level (two-tailed test).

middle- and high-order services. The positive signs associated with household size for middle-order, high-order, consumer durables, and health services supports the hypothesized effect of household size on expenditure through the income effect.

Not only do larger households have more hands to engage in productive activities, they also have more mouths to feed. Holding productive assets constant, this could limit the income available for less basic expenditures. However, for the

Table 44—Ordinary least squares regression results for budget shares of a weighted sample of households

Independent Variable	Dependent Variable						
	LOWSHR	MIDSHR	HIGHSHR	FPSHR	CDSHR	TRANSHR	HEALSHR
Constant	107.026	3.322	0.807	104.619	4.195	1.598	0.0161
	(29.954)*	(1.475)	(1.901)*	(29.177)*	(1.840)*	(3.496)*	(3.919)*
N	-0.218	0.306	0.051	-0.253	0.343	0.001	0.0005
	(-0.960)	(2.132)*	(1.887)	(-1.106)	(2.359)*	(0.020)	(2.539)*
LANDPER	-5.492	2.816	0.619	-6.320	3.071	0.607	0.0052
	(-5.923)*	(4.818)*	(5.622)	(-6.791)*	(5.190)*	(5.123)*	(5.511)*
PNADULT	-4.568	0.778	-0.433	-3.437	0.259	-0.409	-0.0080
	(-1.340)	(0.362)	(-1.069)	(-1.005)	(0.119)	(-0.938)	(-2.300)*
PCH_HH	61.860	-5.118	0.754	55.188	-2.650	-3.473	0.0980
	(3.349)*	(-0.440)	(0.344)	(2.977)*	(-0.225)	(-1.470)	(5.159)*
AGEHH	-0.024	-0.020	-0.008	0.003	-0.025	-0.019	-0.0005
	(-0.565)	(-0.762)	(-1.606)	(0.079)	(-0.927)	(-3.560)*	(-3.262)*
SEX	2.934	0.835	0.174	2.298	0.928	0.363	0.0018
	(2.061)*	(0.931)	(1.033)	(1.608)	(1.022)	(1.994)*	(1.239)
ED	-3.400	1.709	-0.131	-3.786	1.437	0.670	-0.0012
	(-2.679)*	(2.136)*	(-0.871)	(-2.972)*	(1.775)*	(4.129)*	(-0.967)
IRRIDUM	-4.694	1.774	-0.185	-5.185	1.360	0.449	-0.0044
	(-2.829)*	(1.696)*	(-0.941)	(-3.113)*	(1.285)	(2.115)*	(-1.712)*
CYCLE	-31.983	3.845	-0.345	-31.385	2.588	0.908	-0.196
	(-9.936)*	(1.895)*	(-0.902)	(-9.716)*	(1.260)	(2.206)*	(-4.393)*
CAR	49.657	-13.598	6.072	46.412	-3.333	-7.318	0.3744
	(2.239)*	(-0.973)	(2.304)*	(2.086)*	(-0.236)	(-2.579)*	(4.680)*
MOTORCYC	-50.941	-3.962	3.389	-32.258	-3.004	-5.825	-1.0000
	(-0.831)	(-0.103)	(0.465)*	(-0.524)	(-0.077)	(-0.743)	(-4.510)*
TDIS	1.368	-0.423	-0.006	1.345	-0.377	-0.010	0.0001
	(5.937)*	(-2.913)*	(-0.219)	(5.816)*	(-2.570)*	(-0.351)	(-0.478)
LDIS	-5.627	3.807	-0.270	-6.622	2.376	2.419	-0.0089
	(-3.031)*	(3.253)*	(-1.227)	(-3.554)*	(2.006)*	(10.185)*	(-3.461)*
PPDUM	-27.210	-2.066	-0.609	-27.831	-2.330	0.210	0.0027
	(-14.913)*	(-1.796)*	(-2.811)*	(-15.200)*	(-2.002)*	(0.903)	(1.456)
NPDUM	-4.788	-1.312	-0.541	-6.489	-1.520	0.040	0.0159
	(-2.087)*	(-0.907)	(-1.983)*	(-2.818)*	(-1.038)	(0.136)	(6.738)*
CLDUM	1.094	-4.195	-0.270	1.878	-4.161	-0.791	-0.0013
	(0.642)	(-3.904)*	(-1.337)	(1.098)	(-3.825)*	(-3.628)*	(-0.781)
Adjusted R^2	0.61254	0.13509	0.05402	0.63222	0.12559	0.28617	0.21173
F	86.68944	9.46581	4.09524	94.17642	8.78503	22.72917	14.70290

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: The numbers in parentheses are t-ratios. See Table 25 for definitions of the variables.

*Significant at 0.10 level (two-tailed test).

sample households the effect of having more workers clearly offsets any population pressure on the allocation of total expenditures.

Per Capita Land Ownership by Household

The most important productive asset for households in rural areas is land. The results show that households owning more land per person budget more of total expenditure to the more sophisticated services. The shift is particularly striking for health services, for which greater ownership of land has a positive effect across household types.

Households with more land per capita are expected to generate more income per capita and to spend more of that income on the less basic services. Also, since more land can be used to meet subsistence food needs, the ownership of more land is expected to reduce the need to purchase food. In the case of land, the direct and indirect effects are both expected to result in a smaller share of total expenditure being allocated to basic necessities. The econometric results are compatible with this hypothesis.

Nonadult Household Members

Households that have a higher proportion of members who are not adults spend less on health. Negative effects are also observed on transportation (bus service) for noncultivators, consumer durables for paddy farmers, and low-order services for nonpaddy farmers.

The effect that household size has on expenditure patterns through increased income is expected to be mitigated when a greater percentage of the household members are not adults. Nonadults are assumed to be less productive. Also the needs of nonadults are expected to be lower in terms of expenditure. In households where adult needs dominate, budgeting for food might increase to satisfy larger appetites but might also decline in favor of more sophisticated services. Empirically, the results are not clear across households.

Young Children in Households

The findings are only a little clearer with regard to the effect of young children. For the weighted sample, the higher the percentage of household members who are young children the greater the expenditure share for low-order services, food and personal services, and health services. The effect on health services is also found for nonpaddy farmers separately. The income effect seems to be overridden by young children's needs for greater health care.

Age of Household Head

Older heads of households appear to be reluctant to allocate higher portions of total expenditure to purchased health care. This holds for paddy farmers, as well as for the weighted sample. For noncultivators, as well as for the weighted sample, age seems to reduce the propensity to use transportation services. Although older household heads might have had the time to accumulate more income-generating assets, the empirical results suggest that an age-related traditionalism counteracts any indirect effects of age on expenditure patterns through income. Of course, traditionalism could also limit the adoption of improved production technologies, but, since the negative effect is only associated with transportation and health, the tendency being observed is more likely to be the result of a direct association between age and expenditure preferences.

Gender of the Household Head

While it is typically believed that female-controlled budgets are more likely to have higher allocations for food, female heads of household are also more likely to have income constrained by discrimination in access to production inputs. Both effects should lead to a greater allocation of expenditure to the less sophisticated services, although female-headed households might show a preference for health services.

According to the regression results for the weighted sample, male-headed households are actually more inclined to purchase low-order services than are female-headed households. But the budget share for transportation is indeed larger if the household is headed by a man. The share allocated to health care is higher for cultivation laborer households that are headed by males. Nonpaddy farm households that are headed by men conform to the expectation of less budgeting for food and personal services.

Education of the Household Head

The more educated household heads allocate larger shares of total expenditure to middle-order services, consumer durables, and transportation at the expense of low-order services and food and personal services. The more educated paddy farmers and noncultivators, separately, show a greater tendency to allocate expenditures to transportation services.

Greater education should lead to higher incomes and to more cosmopolitan tastes. The regression results confirm that education does lead to more sophisticated consumption patterns.

Irrigation in the Village

Because the survey took place after a period of severe drought in which the area's catchment basins had not been adequately replenished by the monsoon rains, it is expected that the village's capacity for irrigating crops would have a significant effect on household income. Also, since the availability of water would affect cropping patterns, irrigation capacity could directly alter the need to purchase foods not grown by the household.

For the weighted sample of households, better irrigation is shown to encourage smaller allocations of total expenditure to low-order services, food and personal services, and health services, and a larger allocation to middle-order services. The paddy farms are expected to be the most directly influenced by the quality of village irrigation, but the irrigation variable did not prove to be statistically significant. Nonpaddy farmers in better-irrigated villages allocate less of total expenditure to low-order services and food and personal services but more to health services. Better irrigation is associated with lower expenditure shares being allocated to high-order services by cultivation laborers and noncultivators. Also, noncultivators spend more on transportation if they reside in better irrigated villages. It appears that the effect of irrigation on the overall welfare of a village influences household expenditures more than the quality of irrigation affects the consumption patterns of the primary users of irrigation water.

Bicycle Ownership in the Village

If a greater percentage of a village's households own bicycles, then both the bicycle-owning households and the other households have a greater opportunity to avail themselves of this mode of transportation. Bicycling can be useful for carrying a person with a small load for a slightly longer distance than can be covered on foot. The empirical results suggest that villagers, particularly cultivation laborers and noncultivators, use bicycles to reach bus services for traveling to places where middle-order services are available. The bicycle can also be used to reach input and output markets, and thus help in generating additional income, which could encourage consumption of middle-order services and transportation services at the expense of low-order services and food and personal services.

Car Ownership in the Village

The availability of cars encourages consumption of low-order services, high-order services (including fuels), food and personal services, and health services. And the relative accessibility, even if low in absolute terms, reduces the proportion of total expenditure going to bus service. Cars are a more convenient mode of transport than are buses. However, the regression results are not consistent for each class of household.

Motorcycle Ownership in the Village

Slightly better access to motorcycles appears to encourage noncultivators to shift consumption away from low-order services and food and personal services. Like cars, the results are not consistent across household types.

Distance from Village to Bus Service

The farther household members have to travel from their village to reach bus services, the greater the share of total expenditure they allocate to low-order services at the expense of middle-order services. A shift to food and personal services and consumer durables is also observed. For noncultivators a longer distance to the bus stop translates into a reduction in the share of total expenditure allocated to bus service.

Distance from Village to Nearest Center for Low-Order Services

The greater the distance from a village to the nearest center for any low-order service, the larger the share of total expenditure that households in the village allocate to bus service. The shares decline for food and personal services and health services. The expenditure share for low-order services is reduced in favor of middle-order services. It seems that if greater travel is required, households have a preference for middle-order services over low-order services.

Primary Household Occupation

Holding the other variables constant, it appears that a household's primary occupation influences its expenditure pattern. During the drought, nonpaddy farmers consumed more per capita than did noncultivators, paddy farmers, and cultivation laborers, in that order. In contrast to noncultivators, nonpaddy farmers' expenditure shares are higher for health services and lower for food and personal services, low-order services, and high-order services. Paddy farmers have lower shares for low-order services, middle-order services, high-order services, food and personal services, and consumer durables. Cultivation laborers have lower shares for middle-order services, consumer durables, and bus service. For households that are directly employed in crop cultivation, it seems that household consumption is more related to consumption from own production at the expense of expenditures on outside services, at least during a time of drought.

Substantiated Findings

Whereas the findings presented in the main text of the Engel function analysis relate to the effects of total expenditure and the additional effects of household and village characteristics on expenditure patterns, the results of the reduced-form model relate to the combination of direct and indirect effects of household and village characteristics.

Comparing the findings reported for the two approaches, it is confirmed that for nonpaddy farmers more land per capita results in a smaller share of total expenditure being allocated to food and personal services and a larger share being allocated to health care. It is also confirmed that the larger the nonadult portion of household members, the smaller the portion of per capita expenditure allocated to low-order services by nonpaddy farmers. The larger the proportion of household members who are young children, the greater the share for health. If male-headed, a nonpaddy farm household spends a smaller share on food and personal services. A smaller share of total expenditure goes to low-order services and food and personal services if the nonpaddy farmer resides in a better-irrigated village. Greater accessibility of bicycles encourages nonpaddy farmers to shift consumption toward middle-order services. In villages where cars are more accessible, nonpaddy farmers spend more on middle-order services and consumer durables at the expense of low-order services and food and personal services. For nonpaddy farmers, many of the factors that are hypothesized to affect consumption patterns are proven to be statistically significant, using either the reduced-form approach or the Engel function approach.

Fewer hypothesized relationships are confirmed for paddy farmers. The negative relationship between the household head's age and the expenditure share on health is substantiated by the reduced-form estimation. In villages where bicycles are more accessible, paddy farmers tend to spend a smaller share on low-order services. Paddy farm households located in villages farther from bus stops shift consumption toward low-order services and food and personal services and away from high-order services and health services.

Since estimation of Engel functions did not result in statistically significant F-tests for cultivation laborers and noncultivators, no comparison is made with the reduced-form results for cultivation laborers and noncultivators.

APPENDIX 2: SUPPLEMENTARY TABLES

Table 45—Regression coefficients for budget share equations by service group for weighted sample

Independent Variable	Dependent Variable						
	LOWSHR	MIDSHR	HIGHSHR	FPSHR	CDSHR	TRANSHR	HEALSHR
Constant	-247.965	424.405	-35.5237	-365.540	254.560	279.830	-20.0520
	(-0.172)	(0.962)	(-0.915)	(-0.252)	(0.798)	(1.218)	(-0.729)
LOGE	86.9451	-57.5231	5.3870	102.400	-33.254	-38.800	3.3315
	(0.420)	(-0.907)	(0.965)	(0.490)	(-0.725)	(-1.175)	(0.842)
N	3.4999	-2.4024	0.2773	4.1650	-1.2631	-1.7827	0.2092
	(0.362)	(-0.809)	(1.061)	(0.426)	(-0.588)	(-1.153)	(1.130)
PNADULT	34.6844	-25.9137	2.3833	44.047	-15.918	-18.359	0.6916
	(0.351)	(-0.856)	(0.895)	(0.442)	(-0.727)	(-1.165)	(0.366)
PCH_HH	18.5703	-5.8919	-0.6106	17.198	-5.5908	-1.0956	1.7640
	(0.437)	(-0.452)	(-0.532)	(0.401)	(-0.593)	(-0.161)	(2.171)*
AGEHH	-0.2684	0.1492	-0.0207	-0.2698	0.0723	0.0879	-0.0274
	(-0.368)	(0.667)	(-1.053)	(-0.367)	(0.447)	(0.752)	(-1.967)*
SEX	10.9638	-3.2644	0.8742	12.040	-0.67900	-3.4132	0.5047
	(0.409)	(-0.397)	(1.208)	(0.445)	(-0.114)	(-0.797)	(0.984)
ED	-28.9626	18.1265	-1.4815	-34.432	11.391	11.857	-0.8179
	(-0.512)	(1.045)	(-0.970)	(-0.603)	(0.907)	(1.312)	(-0.756)
IRRIDUM	-10.5345	4.8922	-0.6745	-12.234	2.5621	3.3654	0.1410
	(-0.432)	(0.655)	(-1.025)	(-0.497)	(0.474)	(0.865)	(0.302)
CYCLE	30.5777	-38.1598	3.1396	43.038	-22.845	-26.508	1.0225
	(0.208)	(-0.848)	(0.792)	(0.290)	(-0.701)	(-1.131)	(0.364)
CAR	180.156	-101.752	15.5327	202.980	-51.869	-69.942	10.2250
	(0.416)	(-0.765)	(1.328)	(0.464)	(-0.539)	(-1.010)	(1.234)
MOTORCYC	-806.901	528.491	-44.6497	-924.590	314.390	337.420	-40.5790
	(-0.407)	(0.869)	(-0.834)	(-0.462)	(0.714)	(1.065)	(-1.070)
TDIS	1.0198	-0.2196	-0.0100	0.9303	-0.2253	0.1113	-0.0326
	(0.347)	(-2.243)*	(-1.826)*	(0.313)	(-3.885)*	(0.237)	(-0.580)
PPDUM	-309.2920	-11.4390	-2.4930	-306.4700	-13.4900	-1.0861	-1.9343
	(-6.489)*	(-0.783)	(-1.938)*	(-6.370)*	(-1.276)	(-0.143)	(-2.122)*
NPDUM	-211.1120	-11.6286	-1.9878	-209.2000	-11.3840	-4.1125	0.1003
	(-5.232)*	(-0.940)	(-1.825)*	(-5.136)*	(-1.271)	(-0.638)	(0.130)
CLDUM	-224.813	-32.8731	-0.4241	-215.740	-26.373	-14.977	-1.1660
	(-4.589)*	(-2.188)*	(-0.321)	(-4.363)*	(-2.427)*	(-1.915)	(-1.245)

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: N = 337. Numbers in parentheses are t-ratios. See Table 25 for definitions of the variables.
*Significant at the 0.10 level (two-tailed test).

Table 46—Coefficients of ordinary least squares regressions for per capita income equation on weighted sample of four household types

Independent Variable	Dependent Variable: LOGE	
	Coefficient	t-Ratio
Constant	6.9675	52.302*
N	-0.0419	-4.984*
LANDPER	0.2242	6.416*
PNADULT	-0.4899	-3.888*
PCH_HH	0.0609	0.081
AGEHH	0.0049	0.288
SEX	-0.0473	-0.764
ED	0.1537	3.271*
IRRIDUM	0.1048	2.083*
CYCLE	-0.6785	-6.544*
CAR	-2.6007	-3.795*
MOTORCYC	10.9536	6.113*
TDIS	0.0097	0.933
LDIS	-0.0411	-2.356*
PPDUM	-0.0187	-0.255
NPDUM	-0.0353	-0.372
CLDUM	-0.1933	-2.824*
Adjusted R^2	0.5354	
F	25.2019	

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Note: The total sample size, comprising all four types of households, is 337. See Table 25 for definitions of the variables.

*Significant at the 0.10 level (one-tailed test).

Table 47—Regression coefficients for input demand equations for weighted sample including paddy and nonpaddy farms

Variable	Seeds	Fertilizers	Credit
Constant	81.516	-232.207	0.31183
	(0.519)	(-1.997)*	(1.019)
N	-0.190	4.424	0.00430
	(-0.040)	(1.315)	(0.046)
LANDOWN	10.393	8.483	0.00764
	(3.346)*	(3.904)*	(1.263)
PNADULT	2.947	27.837	-0.11987
	(0.036)	(0.460)	(-0.751)
PCH_HH	13.649	0.751	-0.01123
	(-1.113)	(0.010)	(-0.057)
AGEHH	-0.642	1.054	-0.00191
	(-0.567)	(1.297)	(-0.867)
SEX	1.254	-16.634	-0.04186
	(0.028)	(-0.463)	(-0.472)
ED	47.734	35.109	0.00121
	(1.763)*	(1.769)*	(0.023)
SEEDDIS	12.537	12.428	-0.04211
	(-0.828)	(1.135)	(-1.428)
FERTDIS	11.555	24.256	-0.00327
	(-0.764)	(2.135)*	(-0.111)
CREDTDIS	12.109	-25.375	0.00783
	(0.945)	(-2.617)*	(0.314)
TRAILER	40.592	467.858	-1.43588
	(-0.309)	(0.796)	(-0.948)
CYCLE	67.986	123.596	0.28195
	(0.881)	(2.122)*	(1.877)*
CAR	30.877	-2,082.050	-1.10181
	(0.023)	(-2.070)*	(-0.425)
MOTORCYC	46.228	-2,370.110	3.95621
	(1.674)*	(-0.999)	(0.648)
IRRIDUM	44.490	-4.747	0.22158
	(0.583)	(-0.085)	(1.492)
NPDUM	17.593	-1.629	0.07852
	(0.573)	(-0.055)	(1.313)
Adjusted R^2	0.16469	0.19225	0.02476
F	3.11948	3.29080	1.27930

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Notes: The numbers in parentheses are t-ratios. The variables are defined in Tables 25 or 33.

*Significant at the 0.10 level (one-tailed test).

Table 48—Regression coefficients for output market equation for weighted sample including both farm types

Variable	Coefficient	t-Ratio
Constant	-2,750.963	-0.987
NPDUM	-192.193	-0.193
IRRIDUM	2,045.966	1.149
PCH_HH	1,808.817	0.704
SEX	79.691	0.065
CYCLE	3,419.611	2.783*
ED	487.540	0.716
N	65.088	0.563
OUTPDIS	-120.251	-2.505*
AGEHH	0.316	0.012
LANDOWN	325.657	4.382*
MOTORCYC	47,661.119	0.663
PNADULT	194.704	0.095
CAR	-5,376.116	-0.448
TRAILER	-5,872.524	-0.320
Adjusted R^2	0.24998	
F	3.49910	

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

*Significant at the 0.10 level (one-tailed test).

Table 49—Government expenditure on current accounts and special projects, 1982/83

Government Expenditure	Account	Share
	(Rs)	(percent)
Current account		
Education[a]	1,610,956	2.66
Health[b]	5,539,067	9.15
Communication[c]	2,055,815	3.39
Credit and finance[d]	25,231,869	41.69
Transport[e]	17,985,274	29.72
Agriculture and agricultural inputs[f]	6,075,420	10.03
Animal husbandry[g]	1,741,301	2.87
Marketing[h]	274,699	0.49
Total in services	60,514,401	100.00
Special project		
Intensive Rural Development Programme[i]	14,926,000	16.16
Self-Sufficiency Scheme[j]	60,860,000	65.59
National Rural Employment Programme[k]	4,998,000	5.41
Drought Relief Programme[l]	11,550,000	12.84
Total in all special projects	92,334,000	100.00

Source: International Food Policy Research Institute/Tamil Nadu Agricultural University, Field Survey in North Arcot District, Tamil Nadu, India, 1982-84.

Note: Government expenditure does not include factor payments and capital accounts, only receipts.

[a] Includes all education services.

[b] Includes all public health and social welfare services.

[c] Includes all postal and telegraphic services.

[d] Includes all cooperative and commercial banking services.

[e] Includes all road and rail as well as department of transport services.

[f] Includes agricultural research, agricultural marketing, oilseeds, seed certification, and agricultural engineering services.

[g] Includes key village centers and animal husbandry services.

[h] Includes all regulated marketing services.

[i] Includes expenditure on agriculture, animal husbandry, minor irrigation, training and extension, agriculture, fishery, and farm forestry.

[j] Includes expenditure on village-to-main-road link roads, culverts, school buildings, rural dispensaries, maternity centers, village pathways, and minor irrigation.

[k] Includes expenditure on afforestation, drinking water wells, minor irrigation, drinking water, transport, and roads.

[l] Includes expenditure on sinking bore and open wells, deepening of wells, drinking water, transport and roads, improvement in minor irrigation, and new ponds.

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